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The Repairs and Maintenance of Old Iron Bridges.

The history of iron bridge building in this country has been peculiar and interesting in some respects. When the production of iron became so far perfected as to permit the construction of iron bridges to displace those of wood, it was supposed that structures of a truly permanent character had been attained. This expectation was, of course, based upon the great durability of iron as compared with that of timber, yet as a matter of fact, the oldest bridge structures of this country have been those of timber. It must be stated, however, that this is true only in some rare cases where the increase of moving loads has not affected the conditions of life of the structure. Aside from these exceptional circumstances it was reasonable to suppose that bridges of iron and steel would have practically indefinite length of life. This expectation, which undoubtedly held in the early days of iron bridge building, has been defeated chiefly by the great increase of moving railway loads, but also to no small extent by serious defects of early design. These latter found their origin in two sources; first, the failure to realize the imperative necessity of solidity and strength in details and the necessary care in constructing them, and secondly, in insufficient knowledge of the theory of stresses, not only in the main members but also in the principal details. The first of these influences has been so effective in its work of rejection, so to speak, that the actual life of iron railroad bridges has scarcely exceeded 20 years, and in many cases it has not been so great as that. Among the more prominent of these instances of displacement, due chiefly to the rapid increase of moving railroad loads, and to some extent to a more thorough appreciation of the imperative necessity of satisfactory details, are the Kinzua Viaduct and the Rockville bridge across the Susquehanna River near Harrisburg, Pa.

It has become a most important question, therefore, to determine the most effective and economical treatment of these old structures so as to justify either their use or their rejection. It may be stated broadly that where sufficient money is available the immediate displacement of an old structure insufficient in its carrying capacity to meet the requirements of rapidly moving heavy trains by a substantial structure with sufficient margin of strength to carry traffic for many years is the best business policy. Under this view of the case, the displacement of iron trusses by masonry arches now being followed by the Pennsylvania Railroad is undoubtedly one of the most judicious procedures yet made by any railroad corporation in this field of its administration.

All railroad companies, however, are not enjoying equal ease of financial conditions, and it is a necessity for them to retain their old structures just as long as it can be shown to be economical to do so. In such cases the problem of repairs and maintenance, or of the displacement with new structures, becomes of great importance as well as of considerable complication. If a comparatively small amount of money can be expended in strengthening weak details or even sometimes in displacing main members by new and stronger members, so as to enable the bridge to carry its increased loads for a period of years without sensible increase in cost of maintenance, it is certainly good business to follow that procedure. As a matter of fact very few, if any, of the bridge failures of this country have taken place by the collapsing of main members. With scarcely an exception, the failures of iron bridges have been induced by the defects of their details. The Ashtabula disaster had its origin in the failure of a cast-iron detail that under any proper rule of structural behavior should have failed when the falseworks were removed, although the design of some of its main members was sufficiently vicious to destroy faith in them. The Bussey disaster was caused by a hanger of poor design. It is not always easy to displace weak details by those that are stronger, but as a rule it is far easier to do that than to displace a main member, and reinforcement of details has been accomplished in a great number of cases with eminently satisfactory results.

Again, bridge structures of the riveted type have frequently been strengthened by the addition of an extra set of web members in each truss without interfering with the passage of traffic or without expense of serious character. In such cases the chords have been of sufficient carrying capacity to avoid material overstressing by the increased loads, the weak features being the original web members. In certain cases new complete trusses have been introduced with additional or new lateral bracing so as to carry a sufficient portion of the moving load to relieve the old trusses of at least the excess over the loads for which they were originally designed. Wherever the latter procedure may be followed it is quite possible to put the structure in condition for satisfactory use for a long period of years in a satisfactory manner. This course is about to be pursued with the cantilever bridge across the Hudson River at Poughkeepsie.

Just how far these costs of maintenance and repairs of old structures may be carried must be determined on the merits of each case, and the criterion by which the final results are reached is not always of a purely business character. It is clear that if the amount of money to be expended in this line of construction added to the inconvenience or lack of capacity to which the railroad may be subjected as a carrier of freight and passengers expressed in money is greater than the cost of entire reconstruction it would obviously be poor business to maintain the old structure, and such conditions have been met in many cases on the older railroads of the eastern states as well as some other portions of this country. As a rule the objections to an old bridge short in its carrying capacity are not limited entirely to its structural character, as it usually hampers the work of transportation in speed as well as in carrying capacity of trains. In modern railroad work where passenger trains must conform to a fast schedule and where freight must be moved at comparatively high speeds as well as in heavy trains, the limits of cost of maintenance of an old structure reach far beyond the mere matter of structural repairs and that fact explains the vast number of bridge renewals which have been made during the past ten to twenty years. Unless relatively great gain in carrying capacity and in solidity of roadbed can be reached at comparatively small cost in the maintenance of an old structure, it is advisable to consign it to the scrap heap at an early date.

Recent Views of the Sewage Disposal Problem.

Anybody who believes that the problems of sewage disposal have not been receiving very important investigation of late has not kept in touch with this particular branch of engineering. In fact, it may be safely said that, outside of the field of heavy electric traction, no engineering specialty has been advancing so rapidly as that concerned with the treatment of sewage to fit it for discharge into bodies of salt or fresh water. While the last two or three years have not brought forth any particularly novel methods of treatment, they have produced in the United States, Great Britain and Germany a mass of experimental and practical operative data which indicate in some degree what the various methods of treatment will accomplish under ordinary conditions. Owing to the steady progress in adopting methods of sewage analysis which yield fairly comparable results, it is now generally possible to compare the data obtained by one investigator with those secured by another at a different place, at least to some degree. This is a most important matter, for the quantities of organic and inorganic matters in water and sewage are so infinitesimal in comparison with the amount of water carrying them, and are so subject to change, that standard or comparable methods of analysis are essential for any true progress in sewage purification.

The progress made when unhampered by official regulations concerning results to be attained or methods of treatment to be followed has been mainly along the line of reducing the fixed charges and cost of operation. The old idea that sewage farming is the best method of disposal was exploded long ago, and the sewage farms still in service are not kept in operation because they afford the most economical method of treatment, as a rule. The rise of intermittent filtration has similarly reached its culmination. It is acknowledged to be the most perfect method of treatment when all conditions are favorable, but it is now known that it is much more expensive than was formerly anticipated, and the character of the effluent which it furnishes is often unnecessarily good for discharge into the body of water receiving the purified sewage. One by one the intermittent filters constructed in New England a number of years ago under the impetus given to this method of disposal by the admirable investigations of the Massachusetts State Board of Health, are becoming clogged and inoperative except at very low rates, and the heavy initial expense which is usually necessary for such filters is recognized as merely a forerunner of heavy maintenance charges.

Under these circumstances specialists in sewage treatment have been working to ascertain just what methods are best for securing different degrees of purification from the partial clarification resulting from simple sedimentation to the extreme degree of purification attained with the best intermittent filters under the best operating conditions. This view of the sewage problem is emphasized in Mr. George W. Fuller's valuable paper printed elsewhere in this issue and was also brought out early this month in an address by Mr. J. F. Reade before the Civil and Mechanical Engineers' Society of England. The fact that there is no "best" method of disposal is clearly indicated in these papers, for the problem is one of selecting the treatment which will turn a sewage of any given composition into a liquid which can be discharged into a given body of water without creating objectionable conditions in the latter. The problem is thus very different from that of water purification, which has for its object the production of drinking water. The latter is aiming always at a comparatively fixed standard of effluent, while there is nothing definite about the character of effluent from sewage treatment plants in different localities.

Along with this recognition of the varying requirements of sewage treatment are many new suggestions concerning the methods to be followed. The most interesting of these to the engineer who has not been following the development of the subject, is the closer connection which is gradually appearing between the principles of water purification and sewage treatment. Mr. Reade indicated this as follows in his address: "By means of the well-known methods of sand filtration, as practiced in town water supplies, water containing considerable organic impurities can be made to attain a very high degree of purification, both chemically and bacteriologically, by repeated operations. A link is thus established between the two valuable concentrated natural processes of bacterial purification and ordinary sand filtration. They are no doubt intimately related to each other, but in practice it will be impossible to purify raw sewage by sand filtering, and an unfiltered drinking water can scarcely be made fit for use by passing it through a septic tank installation." Mr. Fuller stated the same idea in the following words: "Contact filters, or sprinkling filters, are perfectly capable in connection with a suitable preparatory treatment of producing a non-putrescible effluent containing about 50 parts per million of suspended matter and about 10 per cent. of the bacteria in the raw sewage. Such a liquid is comparable with a turbid river water, which is highly polluted with sewage. In other words, coarse-grain filters reduce a sewage to a state where it can be subjected to the treatment applied for the purification of drinking water from turbid and polluted rivers." In fact, it may be stated with considerable certainty that before many years have passed mechanical filters will form a part of the equipment of some sewage treatment works of large capacity where it is desirable to produce an effluent of a high degree of purity. In other respects, also, sewage treatment is borrowing from water purification some of the latter's methods, such as the use of copper sulphate. In short, the time is coming when water purification and sewage treatment will probably be recognized as the two end forms of one broad problem, the purification of contaminated water.

Developing Export Trade.

The Bureau of Manufactures of the Department of Commerce and Labor is now publishing some interesting information concerning the methods by which American manufacturers make themselves disliked by merchants of other countries to whom they send their products. Just at present the Bureau is preaching the necessity of good packing and showing by photographs the effect of shipping goods to foreign markets in the kind of packages employed for domestic business. A recent bulletin, for example, gave illustrations of broken packages arriving at Tientsin from American shippers of glass, musical instruments, piece goods, clothing, and the like. The wretched condition of these shipments would cause any importer to give up doing business with a house making up such flimsy or improper packages. The trouble is a serious one, and is not given sufficient attention by most American manufacturers. They should keep in mind the fact that not only must the outside of the package remain intact, but its contents must be kept from damage by rough handling. In a general way it would appear that our manufacturers have reached the stage of development where they appreciate the value of a substantial outside package, as a rule, but the necessity of better inside packing is still unrecognized.

All this matter of packing is merely incidental to holding business after it is obtained. Just as soon as American merchants have enough export business to make it worth their time to look into the trade carefully they will make the packing a subject of study, like every other detail of the business. At the present time most manufacturers can make more money in the domestic market than in foreign trade. Some, however, are reaching out for a little over-seas business, and the methods they adopt are unfortunately such as to cause amusement among people who know the conditions of the export trade. The American manufacturer is hampered at the very outset by lack of familiarity with the influence of local prejudices. He is wedded to the idea of standardization in everything, from the general shape of his machines to the paint that goes on them, for the United States is so great and offers a market so large and of such uniformity in requirements that standardization is practicable.

With export business, on the contrary, it is absolutely necessary to allow for the local tastes of the purchaser. The European manufacturer, acquainted with export business from his early youth, knows instinctively just how far it is safe to run counter to the general practice of the districts into which he is introducing his products. The points of real excellence in his designs he will not sacrifice, because on them the future of his trade depends, but if it is a mere matter of the shape of a frame or finish of various parts he makes every required change without the slightest question. On the contrary, the American manufacturer generally claims that every detail of his product is the very best thing possible and will not give in to any of the purchaser's prejudices. The latter is told he can take the product offered him or can leave it, and generally does the latter.

Another feature in which American manufacturers are far behind their European rivals is in the custom of giving credits. Business is done about the same in all parts of the United States, but this is not so in Europe where the German or French manufacturer has learned that export business must be conducted according to the customs of the countries where it is done and not in accordance with those of the home countries. When a foreign purchaser opens negotiations for materials or machines it is natural to require him to conform with the trade customs of the people he approaches, but when a manufacturer opens a branch in any foreign country he must expect to adopt the customs of that country. He cannot carry all his own prejudices into another country and get a warm welcome. It is in this respect that the German manufacturers have shown great shrewdness. Their agents have sometimes spent several years in the countries to which they are assigned, working in humble positions for the class of people to whom they will later sell German products. This is done so as to acquaint their principals with the actual requirements of the district and enable the right products to be made, as well as to gain a sufficient acquaintance with the necessities of the future purchasers to talk intelligently about their business. This system of training agents is very successful, for it results in the capture of markets for German machinery at prices giving good profits, while the flying visits of a talkative American salesman are wholly without any result.

Another respect in which American exporters suffer is through a lack of good literature for foreign trade. Oftentimes the language is astonishingly bad, and in very few cases is the text of the character which will build up trade. These pamphlets ought to tell what machines will do rather than what they are built of. The class of book that is best adapted for the American purchaser is wholly unsuited for most other buyers, and ought to be abandoned in favor of something which will answer the questions that the latter will ask.

Impossible Guarantees.

There is no feature connected with the management of steam plants that has been the cause of more annoyance than that of impossible guarantees, and for this reason it may not be out of place to repeat some opinions on the subject expressed in these pages a number of years ago. The enterprising manufacturer, always bent on getting the most for the money he spends on improvements and desirous of adopting any new machine or apparatus which will reduce his fuel consumption, is frequently led to invest in novelties considerable sums of money, the only warrant for it being a guarantee which sometimes, as it afterwards proves, is impossible of fulfillment. So far as the manufacturer or person representing him is concerned, he cannot, as a rule, be blamed, for a great many of these guarantees appear to be reasonable enough, and they are offered by the party making the sale in such a plausible way that there seems to be no doubt of their success.

Our engineering knowledge comes largely from failures. If a piece of steam machinery is guaranteed to do certain things and it fails, the failure is instructive in showing how much it is capable of doing. The failures that have been made in attempting to fulfill impossible guarantees have caused a vast amount of annoyance but they have also advanced the data of steam engineering and in so far have been of benefit to the profession. The conditions pertaining to boiler work are so much more varied than those surrounding the running of engines that it is not surprising that the most notable cases of this nature refer to the generation of steam, rather than to its use after generation. Here is one. A large plant of boilers was installed under a guarantee that each should evaporate a stated quantity of water per hour with an economy represented by an evaporation of twelve pounds of water from and at 212 degrees per pound of combustible, the coal being Cumberland bituminous. That the stated gross evaporation might be attained, it was necessary that each square foot of heating surface should evaporate over seven pounds of water per hour, or at least twice as much as most stationary boilers are called upon to do. This is not an impossible rate of evaporation if the question of economy is omitted, but twelve pounds of water per pound of combustible represents almost the best performance in the matter of economy, that is attainable under any conditions, and the difficult part of the matter was to satisfy both conditions at once. After repeated atempts to obtain both results, the best that could be done was to evaporate the guaranteed gross amount at an economy of eleven pounds of water per pound of combustible. The rate of combustion was 21.3 pounds per square foot of grate surface per hour, the ratio of heating surface to grate surface, 26 to 1, the evaporation per square foot of heating surface per hour, 7.6 pounds, and the temperature of the flue gases 575 degrees.

The numberless appliances that are attached to steam boilers for the purpose of improving their economy are the subject of many an impossible guarantee. Those who sell these articles refer to cases where as much as 25 per cent. of fuel has been saved by their use, and instances are known where they went so far as to guarantee this amount. Almost any boiler which is fired improperly can be improved by a simple change in the system of firing, and it is not too much to say that the attachment of any apparatus to such a boiler would be of some benefit, however useless in itself, if at the same time improvement in handling the boiler was effected. Where this is done the new device gets the benefit of alleged improvement, to which it is not entitled, and it is believed that many testimonials which certify to improved performance, refer to cases in point. It must be a very inefficient boiler which can be improved 25 per cent. by the attachment of any fuel-saving apparatus, and guarantees of such figures may well be looked upon with suspicion.

Impossible guarantees are sometimes made for the sole purpose of influencing a sale, the party making them being secretly aware of their impossible nature, but at the same time knowing that there is not much probability of a test being made to determine whether the guarantee is fulfilled. At a meeting of the American Society of Mechanical Engineers a member related an experience which illustrates the matter. In buying a certain appliance the salesman made the same guarantee for his article as another party did selling the same thing with much more heating surface. On being asked how he could make such a guarantee, the salesman, seeing he could make no sale, replied that ninety-nine people out of a hundred never made the test, and he could afford to back his article. The remedy for preventing guarantees of this kind lies wholly in the hands of the purchasers of the apparatus. If they require a guarantee they should in some way be fully assured that the terms of the guarantee are complied with before payment is made. Dishonest salesmen would then cease taking chances, and in future offer their steam appliances on the basis of merit alone. Requiring a guarantee and not determining whether its terms are fulfilled, not only renders a purchaser liable to be imposed upon, but it is often a setback to manufacturers offering their products upon a legitimate basis.

Unsanitary Condition of Public Buildings.

A few days ago one of the justices of a minor New York court took occasion to point out the vile condition of some of the rooms of a public building in that city, and attributed their unsanitary state to negligence on the part of the Health Department. This may or may not be the proper place on which to lay the blame, but the chances are only one in a hundred that it is. The plumbing, heating and ventilation of public buildings are often about as bad as they can be. Conditions are permitted, even in schools, that would not be tolerated in apartment houses of very moderate rental. The reason is, not that the state of affairs is neglected, but that no money can be secured for their improvement. Without taking up the defense of the Health Department of New York, The Engineering Record wishes to call attention to the most notorious case of neglect of sanitation in public buildings with which it is familiar. The facts came to light just twenty-five years ago and were fully stated in this journal at the time.

President Garfield was then lying awaiting death from the effect of an assassin's bullet, while Mrs. Garfield was ill from causes which the physicians attributed to the unsanitary condition of the White House. This condition was well known, for the officers entrusted with the management of the building had so reported many times. No money for repairs could be obtained from Congress, however, and so the time when public attention was anxiously fixed on this home provided by the nation for its chief executive was seized as the psychological moment for action by the officer in charge of it. He retained Colonel Waring to make a careful examination of the conditions in the building. The latter found that not one of the soil pipes had anything like proper ventilation and many of them had no ventilation at all. The tank from which the upper part of the house was supplied with water was subject to direct contamination from the main soil pipe and from the ventilator of an interior water closet. Some of the toilet rooms were practically without ventilation. Much of the apparatus was of bad design. The workmanship on the plumbing was fair, but the arrangement of the piping was poor and even bad in places, and did "not conform to what were accepted as the necessary sanitary requirements of a safe dwelling."

It would naturally be thought that a request for funds to remedy a condition thus prominently brought before the whole country would have received early approval by Congress. When the illness of the Prince of Wales some years before was shown to be due to the unsanitary condition of Marlborough House, no time was lost in applying a remedy. The White House case was more flagrant than that which nearly cost Great Britain her present king, because it had been repeatedly brought to the attention of Congress by the officers in charge of the building. The wide publicity given to Colonel Waring's report was expected to have enough influence to secure the money necessary for reconstruction. This journal pointed out at the time, that until the plumbing was pulled out and entirely reconstructed, the White House would be behind the better class of New York tenement houses in its sanitary condition.

All this is, of course, an old story. Yet it is worth bringing up again because, in spite of the publicity given to the condition of the White House during the final days of President Garfield, it was not until a few years ago that a really good system of plumbing was placed in the building. If Congress could not be persuaded to furnish money to keep the White House plumbing in proper condition, even after its state was revealed by Colonel Waring's report, it is not likely that the ordinary municipal buildings will be kept in repair in this respect. It will be easy to get a red rug for the Mayor's office and brass cuspidors for the chief of police, but decent plumbing for the benefit of all the tenants will rarely be afforded by the powers which hold the purse strings. It is useless to blame the health departments or the janitors of the buildings; the place to lay the blame is on the body which makes appropriations.

Notes and Comments.

ENGINEERS' ERRORS resulting in extra work must be taken into account in paying contractors, according to a decision of the Illinois Supreme Court in Chicago v. Duffy. The contract called for the construction of a tunnel under the direction of the city's engineers. Owing to an error in their surveys, it was necessary to blast out considerable rock to get back to the true alignment, and 8,372 cu. yd. of masonry were needed to fill the cavities between the lining and the original surface of the excavation. This masonry would have been unnecessary had the proper lines been given, and the court says the city must pay for it.

THE EFFECT OF RETEMPERING MORTAR of Portland cement and crushed quartzite has been investigated in the laboratory of the Office of Public Roads. There were five briquettes in each set of specimens, one set of neat cement and the others of 1 : 1, 1 : 2 and 1 : 3 mortar. The briquettes were made in three series, A, of mortar put in the molds immediately after mixing; B, of mortar allowed to take an initial set, and then broken up and made into briquettes; C, of mortar allowed to take its final set, and then broken up and made into briquettes. Series B showed practically the same or higher strength than Series A except in the 1 : 3 mortar, where the falling off averaged 81 lb. Series C showed a falling off ranging from 5 lb. with 1 : 2 mortar to 117 lb. with neat briquettes. Enough water was used in tempering to give normal consistency to the mortar.

A TOPOGRAPHIC SURVEY OF IOWA under the direction of the State Geologist has been endorsed by the Iowa Engineering Society, which will request the Legislature to appropriate $3,000 for starting the work. Some topographic surveying has already been done, mostly in the eastern counties, and a line of precise levels is being run between the Mississippi and Missouri Rivers. Maps of this nature are of so much value in many ways that they are in no sense a luxury. In securing the data for them, bench marks and base lines are established, which are of value to local surveyors. In designing water and sewerage systems, establishing highways and locating electric and steam railways, they supply information which greatly reduces the expense of the preliminary surveys. They are essential for correctly reporting the natural resources of the State, and their small cost, particularly when they are prepared in co-operation with the United States Geological Survey, is an insignificant matter in comparison with their value. Massachusetts, New York, New Jersey and Pennsylvania, to mention but a few States, have found such maps highly useful.

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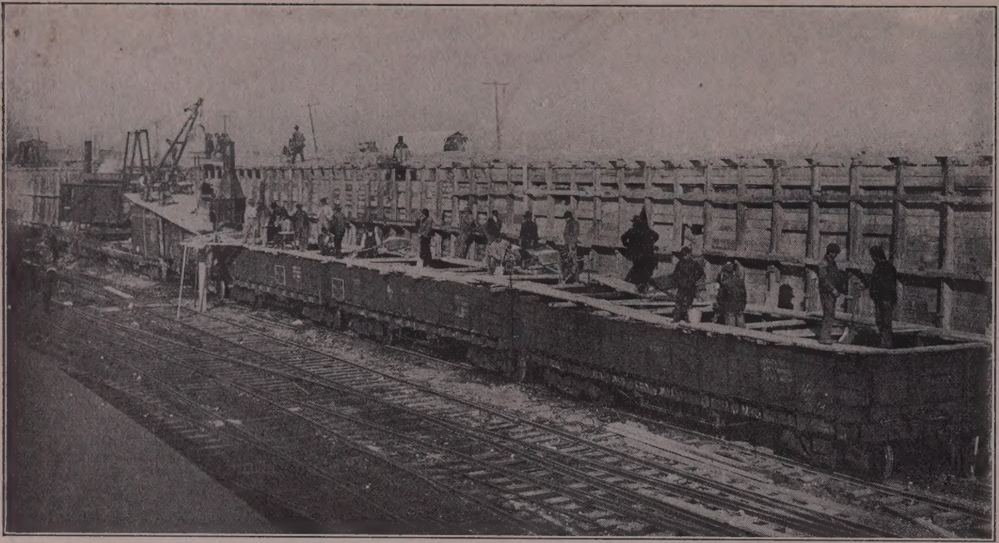


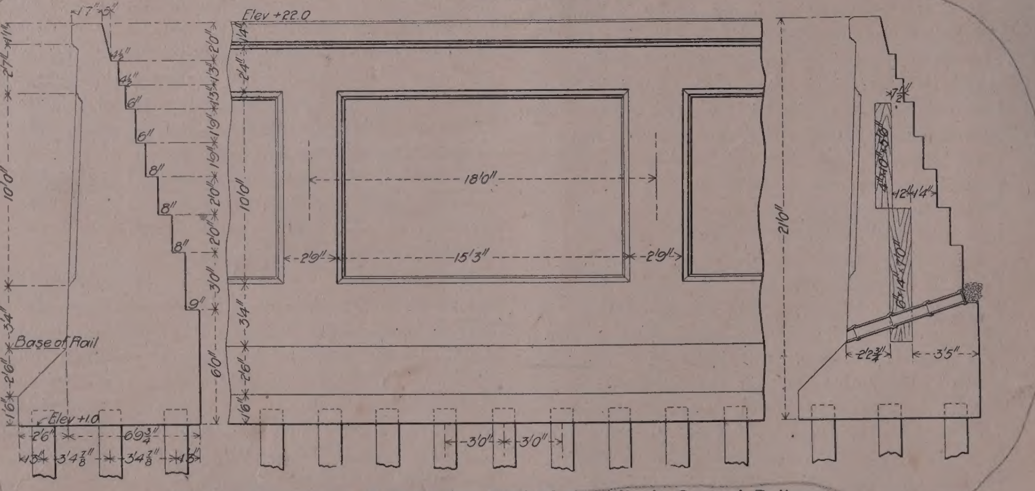
Concrete Train at Work Alongside the South Park Retaining Wall at Chicago.

HEAVY CONCRETE RETAINING WALLS, ILLINOIS CENTRAL R. R.

The Illinois Central R. R. is building a concrete retaining wall 21 ft. high and 6,250 ft. long, on the lake front in Chicago, which is a part of the improvements that are being carried on by the South Park Commissioners of Chicago in making a park along the lake between the latter and the central business district of the city. The park will be approximately 0.75 mile wide and 1.25 miles long, extending from the projected line of Park Row to the projected line of Randolph St. and from Michigan Ave. to a bulkhead 3,000 ft. off-shore from the original bulkhead line. The space between the latter and the outer bulkhead was formerly mostly open water and is being reclaimed to form a portion of the park. The tracks of the railroad company parallel Michigan Ave. and are between 300 and 400 ft. toward the lake from it. The plans agreed upon between the city and the railroad company for the lake front improvements required the former to depress its tracks to an elevation not to exceed 6 ft. above city datum, or 4 ft. below the grade on which they were laid at that time, city datum being the lowest recorded water level in the lake.

The railroad company owns a 200-ft. right-of-way through the area that the park will occupy, over which it carries a very heavy freight and suburban passenger traffic. In order to conceal the movements of the trains on the tracks on the right-of-way a masonry retaining wall 21 ft. high on each side of the tracks, was included in the plans for the improvements and the park will be graded to the top of these walls. The first of the work on the park was done in 1890. During the following two years the railroad company depressed its tracks, built a rubble-masonry retaining wall on the land side of them and erected a large underground station for suburban traffic about midway in the park area. The narrow strip of land between Michigan Ave. and that retaining wall was also brought to the proposed grade and made a park about the same time by the city.

Since the completion of that work the reclamation of the land on the lake side of the tracks had been carried on until recently in a desultory manner with such material as was available from the street cleaning department and from dredging work in the Chicago River. This work has been taken up in the last year, however, with a view of carrying it to completion as rapidly as possible. The Illinois Tunnel Co., which is now operating upwards of 35 miles of freight tunnels under the streets in the business district of Chicago, has built a double-track incline connecting its underground system with tracks on the fill on the lake side of the Illinois Central tracks. Practically all of the excavation for large buildings and a large portion of the ashes and other rubbish in the district served by the tunnels is being hauled out in cars on tracks in the latter and dumped in the fill, over 600,000 cu. yd. of good filling material having been handled in this manner. The United States government is doing extensive dredging in the outer harbor and the material excavated in this work is also being utilized in reclaiming the area back of the bulkhead on the harbor line along the proposed park front. The dredging work in the lake and practically all of that done in the Chicago River has been carried on by the Great Lakes Dredge & Dock Co. This company also has the contract for rehandling all the dredged material dumped in the area to be reclaimed and has placed about 2,000,000 cu. yd. back of the bulkhead in the last 3 years. In the last two seasons the fill has been built up 4 to 8 ft. above datum by hydraulic methods.



General Dimensions of Retaining Wall of the Illinois Central Railroad.

The retaining wall on the lake side of the tracks was the only part of the improvements to be made by the railroad company which had not been completed for several years. The railroad tracks are largely on filled ground, the fill having been made to raise the grade from its original elevation at about the level of the lake. This fill was made with various kinds of rubbish and city wastes, and the old trestles on which some of the tracks were formerly carried were left in place when the grade was raised. The center line of the new retaining wall is on the line of the outer timbers of an old rock-filled timber-crib breakwater for 3,000 ft., and for 1,400 ft. in another place the wall was built over an old trestle.

The base of the wall is 1 ft. above city datum and is 9 ft. 3¾ in. wide. The wall is built on 3 longitudinal rows of piles, the rows being on 3-ft. 4⅞-in. centers and the piles in the rows on 3-ft. centers. The piles are cut off 9 in. above the bottom of the wall, or 3 in. below the approximate water level. The rear face of the wall is vertical for 6 ft. from the bottom and is stepped the remaining distance to the top of the wall, while the front face is battered at 45 deg. from the bottom to the level of the base of rails of the tracks, 4 ft. above the bottom. The remainder of the front face is battered 0.5 in. to the foot to the lower edge of the coping, 1 ft. 4 in. from the top of the wall, and has 10x15.25-ft, panels, 4 in. deep, on 18-ft. centers in it, the panels being moulded on all four edges. The back face is stepped until the width of the wall is 18 in. at the lower edge of the coping. The maximum cross-sectional area is 103.77 sq. ft., the minimum 100.66 and the average, 101.25. The wall is designed for an 8-ft. surcharge, although in places the fill will probably not be carried up to the coping. With this amount of surcharge the resultant load is 31,750 lb. per linear foot of wall, or 1.704 tons per square foot of base, which brings 15.87 tons on each pile. With a fill level with the top of the coping the corresponding results are 26,400 lb., 1.412 tons and 13.2 tons, respectively.

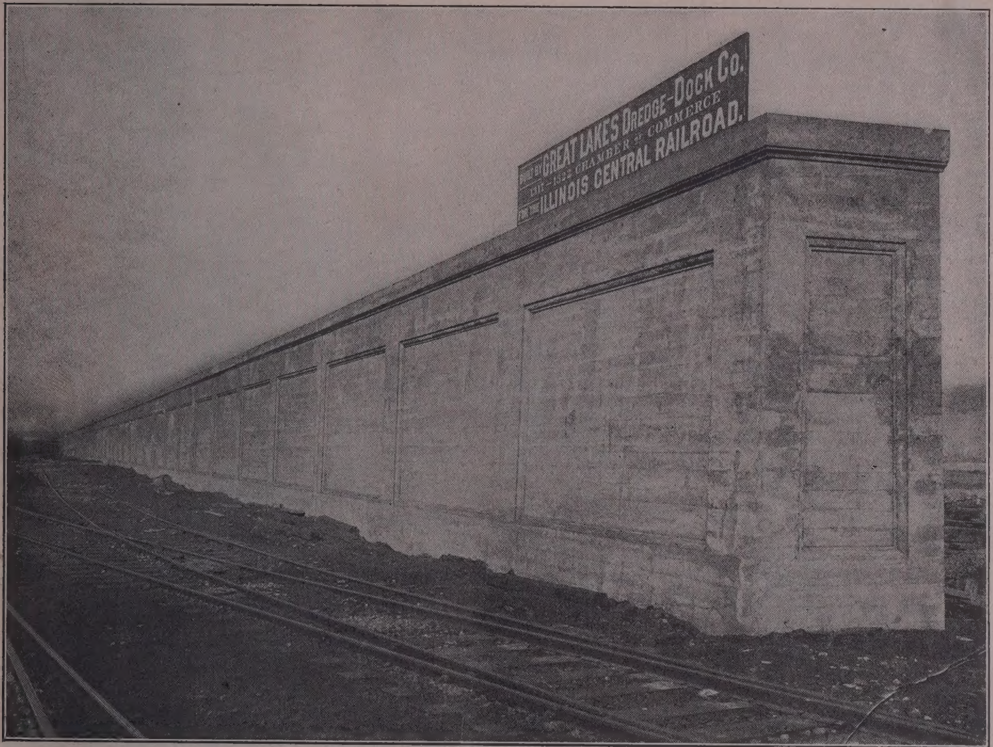
The concrete is mixed wet in the proportions of 1 part cement, 3 parts sand and 6 parts stone. Owl Portland cement and crushed limestone furnished by Dolese & Shepard Co., of Chicago, are used. The front face of the wall and the coping are finished with mortar laid as the concrete is laid. The remainder of the concrete is left as it comes from the forms.

Considerable difficulty was experienced in driving the piles for a large part of the wall. Where the old breakwater was encountered the two timber stringers along its outer line were removed and the old piles in the breakwater sawed off at the required height for the piles under the wall. The regular piles were then driven in the usual manner. Where the wall was built over the old trestle the caps and stringers of the latter were first removed, then after the posts had been sawed off the regular wall piles were driven. The wall piles are 30 ft. long and are followed 2 ft. into the trench. In some cases, however, the presence of rock in the old breakwater very materially interfered with the pile driving, requiring some of the piles to be sawed off after a penetration of

Reengrave cut only ← Reduce to 4" →

a few feet. Two 5-ton steam hammers were used in sinking the piles. They were mounted on runways laid on timbers placed transversely across the trench. Two 10-hr. shifts were worked on each driver and 40 to 45 piles were driven on the average with each machine during each shift. Some water was encountered in the trench, but it did not interfere seriously with the work and was handled by pumps mounted on flat cars on the track along the trench.

The wall was carried up in four courses. The first course extends from the bottom up to the level of the base of rail, this part of the concrete being laid without joints and as continuously as possible. Between that level and the bottom of the panel is the second course, in which expansion joints are placed every 108 ft. on the center line of the pilasters between the panels. The third course extends from the bottom of the panel to the bottom of the coping and contains expansion joints every 54 ft. The coping makes up the fourth course and is laid before the third one has set. Each of the first three courses is sloped 2 in. on top and has a 6x12-in. timber laid in the top to make a key that will bond the adjacent faces of the courses together. A 6-in. drain tile was placed longitudinally along the back of the wall on the tread of the bottom 9-in. step and connected at intervals with pipe through the wall, the tile being laid on a grade sufficient to carry the drainage to the outlets. The expansion joints are filled with one thickness of Hydrex felt and the concrete is laid in alternate sections between the joints so there will be true parting planes at the latter. The end of the section laid first is bulkheaded and vertical timbers are nailed to the inside of the bulkhead to form a key-way for the end of the next section.



A Portion of the Completed Wall at South Park, Chicago.

The lagging on the forms consists of 2-in. planks dressed on one side. The forms for the two lower courses are built first, the planks in the vertical portion being nailed to 4x4-in. posts on 3.5-ft. centers; above that the forms for the faces are nailed to 2x10-in. uprights 3.5 ft. on centers. The steps in the back face are made by nailing triangular-shaped pieces to the inclined uprights for the forms for that face. Each upright in that form is bolted at the bottom to one of the 2x10-in. planks to which the lagging planks for the inclined part of the footing form are nailed. Each of these uprights is also paired with one in the form for the rear face that is bolted in a similar manner at the bottom, and the two are each bolted to a transverse timber at the top. The planks and timbers in the forms can thus be used repeatedly, and are easily taken down and erected. The panel forms are erected separately, but are supported by the main wall forms.

The wall will contain 22,700 cu. yd. of concrete when completed. Of this amount 18,000 cu. yd. were laid in 3 months and then the work was stopped on account of cold weather. Three mixing outfits are used in making the concrete. Each outfit consists of a string of 8 or 9 cars on the track which closely parallels the wall. A mixer is placed on a flat car near the middle of the string, with 4 or 5 cars of sand, cement and broken stone in the rear of this car. Plank runways are laid along the tops of the material cars to the mixer car and the materials are hauled on these to measuring boxes above the mixer. The mixer discharges into a 1-yd. bottom-dump bucket which is handled between the mixer and the wall by a locomotive derrick. This derrick is mounted on a track laid on 3 flat cars in front of the mixer car, and has a travel on the track of 60 to 70 ft., permitting a section of the wall to be finished without moving the outfit. A Drake mixer is installed in one of the outfits and is used in making the concrete for the lower part of the wall. The other two outfits each have a Smith mixer and are used in building the upper part of the wall. Two 10-hr. shifts were used continually on these outfits, 125 to 130 cu. yd. of concrete a day being laid by each outfit during a 10-hr. shift.

The construction of the wall was necessarily rushed and a very limited time was available in which to complete it. The contractors were several days ahead of the required time when cold weather set in and can finish the wall in about 18 days when the season opens, if the same rate of progress can be maintained. The Great Lakes Dredge & Dock Co., of Chicago, has the contract for the construction of the wall, Mr. T. C. Lutz having general supervision and Mr. George Tamm being directly in charge of the work for the contractor. The wall was designed and is being built under the direction of Mr. R. E. Gaut, engineer of bridges on the Illinois Central R. R. Mr. H. H. Hadsall, assistant engineer of bridges, has immediate direction of the design and construction and Mr. J. N. McLoughlin, assistant engineer, is in charge of the work in the field for the railroad company.

The Development in the Uses of Cement.

Presidential Address of Richard L. Humphrey before the National Association of Cement Users.

It is an old but trite saying that "there is nothing new under the sun," and I am taking this opportunity not for the purpose of relating anything new, but merely to refresh your memory on the facts concerning the increasing uses of cement. The use of cement is very old. That the ancient Phœnicians and Egyptians understood the use of mortar is attested by the ruins of their massive masonry structures, the joints of which contain hardened mortar. It is stated by some writers that there is evidence of the use of mortar as far back as 4350 B. C. That the Romans made use of mortar at an early date is shown by the writings of Vitrivius, but we also learn from Pliny that these mortars were bad, for he tells us that "the cause which makes so many houses fall in Rome resides in the bad quality of the cement."

From the downfall of the Roman Empire to the beginning of the eighteenth century, the manufacture of cement seems to have been discontinued. Such cement mortars and concretes as survived the ravages of the elements had become so hard that Roman cement acquired a reputation for quality which led the earlier experimenters of the eighteenth century to seek to recover this lost Roman art. You are all doubtless familiar with the impetus the use of cement received through the experiments of John Smeaton in 1756, by the patent issued to Parker for the manufacture of Roman cement in 1796, and by the experiments of Vicat and Collet-Descotils.

Portland cement proper, however, did not receive its birth until 1824, when John Aspdin received his patent for manufacturing Portland cement, which he so named from its fancied resemblance to the building stone obtained from the Isle of Portland. From this date to 1850 very little progress was made in England. In other parts of Europe the development from 1855 was steady and continuous.

Natural cement was first manufactured in this country by Canvass White in 1818 and reached its maximum development in 1899.

It was not until 1872 that American Portland cement was manufactured by David O. Saylor, in Pennsylvania, in an experimental way. Three years later he was able to manufacture it successfully, and our first Portland cement was exhibited at the Centennial Exposition in 1876. The slow development of this industry was due largely to the strong prejudice against the American Portland cement.

The successful introduction of the rotary kiln in 1889-1890 marks the beginning of the rapid and remarkable development both in the production and consumption of American Portland cement. The contrast between the capacity of the first cement plant built in this country and the modern Portland cement plants having capacities of from 2,000 to 10,000 barrels per diem, is just as great as the contrast between a yearly production of 335,000 barrels in 1890 and the nearly 27,000,000 barrels produced in 1905. And this development is now not confined to one or two points, but is spreading over the entire country.

While it is true that the use of cement in mortars for binding together masses of masonry or in concrete is very old, its use in the construction of arches, beams, columns and other structural parts is quite recent, and the remarkable development in the divers uses to which it is put is all within the recollection of the present generation. These uses may be grouped as follows: (1) In mortars, binding together large masses of stone or brick, etc., or for casting various forms, artificial stone, hollow block, brick, etc. (2) As concrete in mass or under conditions where it is only subjected to compressive stresses. (3) As reinforced concrete where it is subjected to both tensile and compressive stresses.

For the first part of group 1 it will be sufficient to observe that cement mortar is rapidly replacing lime and natural cement mortar.

It is worthy of record that on Nov. 17, 1850, Jos. Gibbs obtained a British patent for casting solid walls of concrete in wooden forms, while on March 6, 1866, C. S. Hutchinson obtained a United States patent for hollow block and brick walls making continuous vertical air spaces, and on April 14, 1874, T. B. Rhodes also obtained a United States patent for hollow blocks and shingles. Patents were granted to C. W. Stevens for the manufacture of artificial stone in 1897, and to J. C. McClenahan in 1902.

The manufacture of artificial stone is now making rapid progress and is successfully competing with cut stone work of ornamental character, both in price and quality.

In the manufacture of hollow block there has been very unusual development. Indeed, it has been so rapid and has appeared so attractive as a field for investment that inexperienced persons with insufficient capital have rushed into the business and the result has been the manufacture of poor material which has not been acceptable to the builder, and this has contributed no little towards retarding the development. This class of building material has come to stay and it will only be a question of time when matters will so adjust themselves that first-class material will be uniformly produced and it will form a very desirable substitute for brick and stone, and in cheapness will eventually compete with wood.

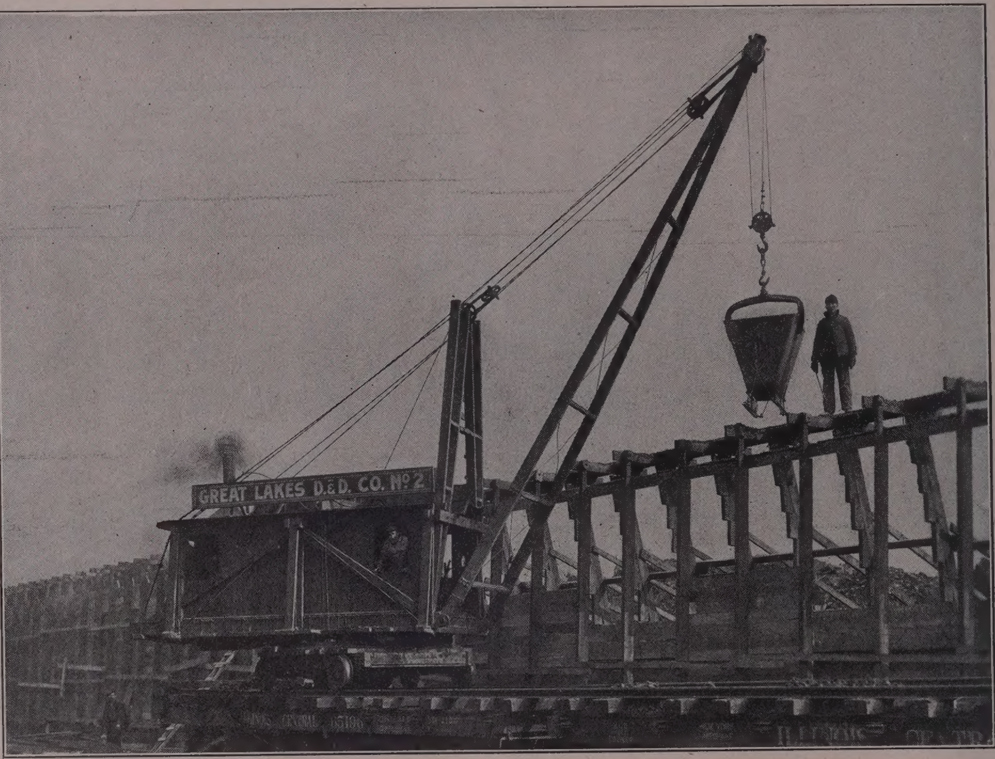
The use of cement has been quite general for many years for sidewalk work, and pavements of this character are by all odds the best attainable. As concrete, however, is deficient in edge strength it has been found necessary to apply steel protection to the edges and there are excellent types of patented steel-bound curbs on the market. The use of concrete for piers, abutments and arch bridges without steel reinforcement is too general to need comment. Additional information, however, is greatly needed as to the proper means for providing for the expansion and contraction of concrete in large masses. The first concrete arch bridge was built in this country in 1870 in Prospect Park, Brooklyn, and to the Erie R. R. is given the credit of having lined the first tunnel with concrete, namely that at Bergen, N. J., in 1874.

A notable development in the use of concrete for bridges is illustrated in the construction of the bridge over Rock Creek in Washington. The voussoirs for the arches of this bridge are molded separately, are then air-hammered, dressed and then hoisted into position. These blocks are handled similar to stone, holes being cut for the dogs. The spaces between these rings and the spandrel walls are cast in place with concrete. No sand is used in the concrete for the arch ring, the crushed rock screenings being substituted and the bluish tint of the rock produces a marked contrast to the color of the concrete used in the spandrel walls, in which a yellowish sand is used.

Concrete sewers and retaining walls, harbor bulkheads of plain concrete are also so extensively used that they are no longer a matter of special interest.

Reinforced concrete, however, is of more recent development. The use of reinforced concrete was probably known prior to 1855, for at the Paris Exposition in that year a system was exhibited by Lambot. In 1861 Coignet proposed a method of reinforced concrete construction. The first application of metal reinforcement for concrete by Monier was in 1867 in the construction of some very large flower pots; in 1868 he obtained his first patent for reinforced concrete, but it was not generally used until after 1880, although in 1879 he exhibited at the Antwerp Exposition a system of such construction.

The first reinforced concrete construction in this country is credited to W. E. Ward in 1875, who erected a house having the floors and columns of reinforced concrete. It should be noted that in 1876 Thadeus Hyatt, an American engineer, published his experiments on reinforced concrete in the laboratory of Kirkaldy, London, England. The experimental work of Hyatt extended from 1870 to 1880. The first Ransome patent was taken out in 1882, and it was applied in the construction of his first building in 1884. Between 1891 and 1894 Möller in Germany, Münsch in Hungary and Melan in Austria were pioneers in the development of reinforced concrete construction in Europe. The use of reinforced concrete on a large scale began in Germany under the system of Möller in 1893 and Rabits in 1898. Hennebique had built reinforced concrete floors as early as 1879. It was not, however, until 1892 that he obtained a patent for his system.



Derrick Car Traveling on Flat Cars, Illinois Central R. R. Retaining Wall.

The last ten years has seen a very remarkable development in reinforced concrete construction. At first reinforced concrete was used largely in the construction of bridges, the first of which was built in this country over the Pennypacker Creek in Philadelphia in 1893, and for which I had the honor of inspecting the cement and other materials as well as the construction of this bridge. From this beginning the use of reinforced concrete has developed rapidly, and we find it is used in almost every conceivable form of construction, large sewers, water pipes, reservoirs, coal bunkers, pneumatic dams, chimneys, grain storage bins, bridges, buildings being some of the many applications.

Experiments have been made in the Reclamation Service for its application in large reinforced concrete pipes of 5 ft. in diameter and capable of standing upwards of 70 lb. pressure, while one of the most novel and recent applications of reinforced concrete is for reinforced concrete crib work, under the Frazer system, which it is stated costs little more than timber cribbing, and has been used extensively in Canada. Chimneys 350 ft. in height have also been successfully constructed of reinforced concrete. The Harvard Stadium, the baseball stand in Cincinnati and the Stadium of the Washington University at St. Louis are all novel examples of the use of reinforced concrete, while concrete ties reinforced in various ways have been in use for some time, though they have not been entirely satisfactory. The cost of maintenance, however, has been found to be reduced to a nominal sum and the alignment has been found to be very easily maintained, which greatly offsets the first cost. The rigidity of the roadbed, however, has been a prime objection, and an effort is now being made to introduce an elastic cushion in the tie in order to overcome this objection.

It is in the erection of office buildings of considerable height that the development has been most remarkable. Buildings of 18 stories in height are being erected in which the skeleton is of reinforced concrete. Considering that the use of steel for reinforcing concrete beams was not suggested until 1882 a development of this character is certainly remarkable and we have reason to pause and consider whether such extreme development is wise.

While visiting a large city recently I had occasion to inspect a building several stories in height in which cinder concrete was being used in the structural parts. The contractor, in reply to my surprised query, stated that the building was still standing. This was indeed true, but what was the margin of safety in this structure? As this concrete had a compressive strength of about half of what could be expected from a fairly good concrete, the factor of safety had therefore been cut in half. In further explanation he stated that in order to compete with other contractors he was obliged to use the same materials which they did.

The use of inferior materials should not be permitted in reinforced concrete construction, and the present situation in the development of concrete and reinforced concrete is one that should be faced squarely. That it is possible to erect a 16-story building of reinforced concrete has been demonstrated, but we should have a better knowledge of the properties of this material before such a practice becomes general. Ten years' or less experience with a material in which chemical changes are constantly going on and which may be affected by the changes produced by expansion and contraction is hardly sufficient to enable us to obtain a thorough knowledge of its properties.

The American Society of Civil Engineers recognized the vital importance of this subject and recently appointed a committee on concrete and reinforced concrete with instruction to affiliate itself in its work with similar committee of the American Society for Testing Materials, the American Railway Engineering and Maintenance of Way Association and the Association of American Portland Cement Manufacturers. After over a year's work they have found that:

(1) Thoroughly reliable data upon which they can formulate a report as to the rules and formula to be used in the design of reinforced concrete structures do not exist.

(2) The results of the tests made in the laboratories of the various technical institutions are not sufficiently comparable nor correlated for the purpose of obtaining this data.

(3) In order to secure the requisite data it will be necessary to conduct a complete series of tests in one laboratory where the conditions are as uniform as it is practical to obtain them and where the personal equation is reduced to the minimum.

This requires considerable money; fortunately the small appropriation made to the United States Geological Survey for the investigation of structural materials has been applied to this work and the investigations have been inaugurated, under the direction of an Advisory Board on Fuels and Structural Materials, by the United States Geological Survey in co-operation with the Joint Committee on Concrete and Reinforced Concrete of the American Society of Civil Engineers and affiliated societies. In the absence of reliable data and under the conditions in the present state of the art the courage to erect 18-story buildings must command our admiration. I do not wish it to be deemed pessimistic or overly conservative, for my belief in the future of concrete and reinforced concrete is absolutely unshaken, and I feel that the use of cement will so expand during the next few years that it will be beyond the limits of its most ardent advocate, but I do wish to point out the dangers which will result from its indiscriminate and foolhardy use and to protest against the people who rush in and guarantee ridiculous things in concrete construction.

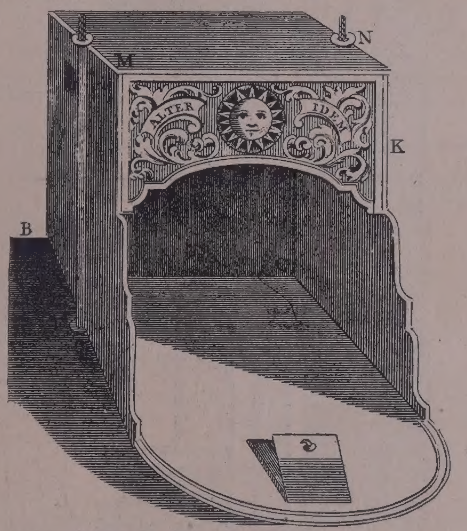
Concrete fills an important and growing field, but it has its weaknesses and its limitations and this should be pointed out and recognized squarely by its advocates. It is evident to any one who delves into the subject that reliable data for use in a design of concrete structure is very much needed, and the work the Joint Committee on Concrete and Reinforced Concrete is doing in co-operation with the United States Geological Survey should receive the encouragement and support of each one present, and I would ask you to use every effort in urging upon your Congressmen the vital importance of securing an appropriation for the continuance and completion of this very important work. For the attainment of reliable and uniform data for use in the design of structure in concrete and reinforced concrete will insure a more rapid, safe and successful development in the use of cement.

Benjamin Franklin, The First American Heating and Ventilating Engineer.

An address before the American Society of Heating and Ventilating Engineers, by Albert A. Cary.

The American Society of Heating and Ventilating Engineers happened, by some strange coincidence, to hold its present annual meeting on Jan. 17, 1906. Two hundred years ago upon this same day of the month, Benjamin Franklin was born and upon this bi-centennial anniversary of his birth it seems but fitting that some recognition should be given to this great man by this Society, as he was undoubtedly the originator of what has been commonly recognized as American practice in heating and ventilation.

During the 84 years of his busy life he devoted himself to many pursuits, including literature, politics and science, and he was widely acknowledged both at home and abroad as being a master in all of these directions. The part of his scientific investigations which appeals most to us is his invention between the years 1740 and 1745 of what he called the Pennsylvanian fireplace, which excellent design was afterwards imitated and changed until in many cases its original design and principle were entirely lost sight of and we find many of these so-called improvements bearing the name, even to-day, of the Franklin stove.



Franklin's Pennsylvanian Fireplace.

The fact that fuel was growing scarcer and dearer every year caused Franklin to revolt against the fearfully wasteful manner in which such fuel, principally wood, was being used, and his investigation caused him to make a careful study of all the different methods of house heating. After studying their various faults, he was finally led to invent the Pennsylvanian fireplace which resulted in great economy of fuel and in a properly heated room, something hardly known at that time in the sense that we consider a room to be properly heated to-day.

The real Franklin stove was not the mere iron fireplace which has masqueraded under that name, but it was an apparatus which took cold fresh air from outside the house and after warming it in passages kept hot by the escaping gases of the fire, finally discharged it into the room. Had this old original Franklin fireplace been enlarged and slightly altered and placed in the cellars of our houses, it certainly would have become the prototype of all of our hot air furnaces.

Franklin died April 17, 1790, and left a large amount of literary work behind him which had hitherto been unpublished. Much of this pertained to the history of his life, and this matter was bequeathed to his grandson, no doubt the intention of the testator being that he would further its publication.

Shortly after the death of Franklin this grandson hastened to London, thinking that the best market for literary projects, and began negotiations with several publishers, but on account of what was considered in those days the very large price he asked for this matter, there was considerable delay in having it accepted. During that time the grandson suddenly withdrew these manuscripts from the market and they disappeared and have never been properly traced. After this initiative effort, all available writings of Dr. Franklin and writings concerning his life were gathered together, and finally, 26 years after his death, or in 1806, just 100 years ago, these collected works on philosophy, politics and morals were published in London. As most of the matter in these books comes directly from Benjamin Franklin's pen, such as his description of the real Franklin stove and his method for ventilating rooms heated by these stoves, as well as his studies concerning the action of smoke and chimneys and his invention of a new stove for burning bituminous coal, I would suggest as a fitting memorial by the American Society of Heating and Ventilating Engineers, that the papers concerning these matters be reproduced in our Transactions, that the matter may be available for all of our members as well as others who have occasion to consult our Transactions. As I am the fortunate possessor of this old edition of Franklin's works, I would be pleased to lend it to the secretary of the Society until the matter could be put in print with its accompanying plates of sketches and drawings.

As I believe that extracts from Dr. Franklin's description of his Pennsylvanian stove, its field of usefulness, and the condition of the art of house heating in America at that time may prove interesting, I will, with your permission, read from this old publication.

This description was first published in Philadelphia in 1745.

The growing scarcity of wood for fuel, as mentioned in the first part of this description, is as follows:—

"In these northern colonies the inhabitants keep fires to sit by generally seven months in the year; that is, from the beginning of October to the end of April; and, in some winters, near eight months, by taking in part of September and May.

"Wood, our common fuel, which within these hundred years might be had at every man's door, must now be fetched near one hundred miles to some towns, and makes a very considerable article in the expence of families.

"As therefore so much of the comfort and conveniency of our lives, for so great a part of the year, depends on the article of fire, since fuel is become so expensive, and (as the country is more cleared and settled) will of course grow scarcer and dearer, any new proposal for saving the wood, and for lessening the charge, and augmenting the benefit of fire, by some particular method of making and managing it, may at least be thought worth consideration."

Some of the arguments offered in Dr. Franklin's description are extremely interesting on account of his treatment of the theory of heat. At that time the materialistic theory of heat was generally recognized, which considered fire as a substantial material having weight and substance instead of being considered as merely a mode of motion in accordance with our present theories. Dr. Franklin states:

"1. Fire (i. e., common fire) throws out light, heat, and smoke (or fume). The two first move in right lines, and with great swiftness, the latter is but just separated from the fuel, and then moves only as it is carried by the stream of rarefied air: and without a continual accession and recession of air, to carry off the smoky fumes, they would remain crouded about the fire, and stifle it.

2. Heat may be separated from the smoke as well as from the light, by means of a plate of iron, which will suffer heat to pass through it without the others.

3. Fire sends out its rays of heat as well as rays of light, equally every way; but the greatest sensible heat is over the fire, where there is, besides the rays of heat shot upwards, a continual rising stream of hot air, heated by the rays shot round on every side.

These things being understood we proceed to consider the fire-places heretofore in use, viz.

1. The large open fire-places used in the days of our fathers, and still generally in the country, and in kitchens.

2. The newer-fashioned fire-places, with low breasts, and narrow hearths.

3. Fire-places with hollow backs, hearths, and jams of iron (described by Mr. Gauger, in his tract entitled "La Mechanique de Feu") for warming the air as it comes into the room.

4. The Holland stoves, with iron doors opening into the room.

5. The German stoves, which have no opening in the room where they are used, but the fire is put in from some other room, or from without.

6. Iron pots, with open charcoal fires, placed in the middle of the room."

After giving a more detailed consideration to the fireplaces he has classified under the first and second headings, which consisted of the old-fashioned fireplaces with which we are all more or less familiar; fireplaces in which we could stand, with their big fire-dogs or andirons capable of supporting large logs of wood, and found in the older houses along the Atlantic seaboard, Dr. Franklin then comments upon these two styles of fireplace. The first is the large one I have just described, and the second, a modification of this large old-fashioned fireplace, having its opening somewhat contracted in both width and height. In this comment he again considers heat to be a material body, stating:—

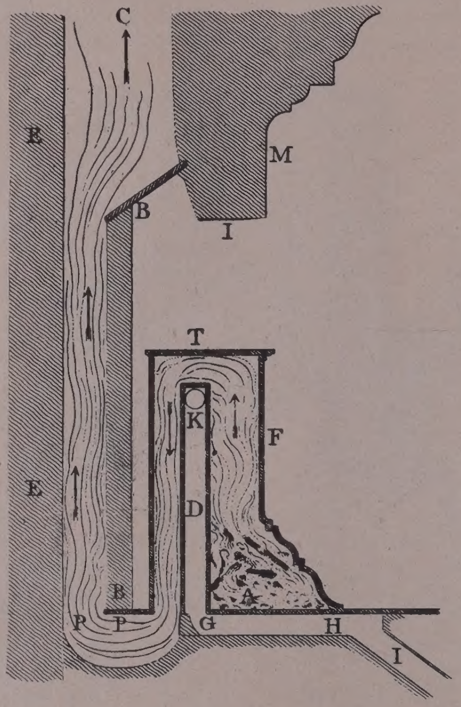
"In both these sorts of fire-places, the greatest part of the heat from the fire is lost; for as fire naturally darts heat every way, the back, the two jambs, and the hearth, drink up almost all that is given them, very little being reflected from bodies so dark, porous, and unpolished; and the upright heat, which is by far the greatest, flies directly up the chimney. Thus five-sixths at least of the heat (and consequently of the fuel) is wasted, and contributes nothing towards warming the room."

After following this comment with a description of his third classification of fireplaces, he takes up the Holland stove and his comments concerning it show his clear conception of the manner in which stoves of this type heat a room. He states:

"The Holland iron stove, which has a flue proceeding from the top, and a small iron door opening into the room, comes next to be considered. Its conveniencies are, that it makes a room all over warm; for the chimney being wholly closed, except the flue of the stove, very little air is required to supply that, and therefore not much rushes in at crevices, or at the door when it is opened. Little fuel serves, the heat being almost all saved; for it rays out almost equally from the four sides, the bottom and the top, into the room, and presently warms the air around it, which, being rarefied, rises to the ceiling, and its place is supplied by the lower air of the room, which flows gradually towards the stove, and is there warmed, and rises in its turn, so that there is a continual circulation till all the air in the room is warmed. The air, too, is gradually changed, by the stove-door's being in the room, through which part of it is continually passing, and that makes these stoves wholesomer, or at least pleasanter than the German stoves, next to be spoken of. But they have these inconveniences. There is no sight of the fire, which is in itself a pleasant thing. One cannot conveniently make any other use of the fire, but that of warming the room. When the room is warm, people, not seeing the fire, are apt to forget supplying it with fuel till it is almost out, then, growing cold, a great deal of wood is put in, which soon makes it too hot. The change of air is not carried on quite quick enough, so that if any smoke or ill smell happens in the room, it is a long time before it is discharged. For these reasons the Holland stove has not obtained much among the English (who love the sight of the fire) unless in some workshops, where people are obliged to sit near windows for the light, and in such places they have been found of good use."

He then proceeds to give a description of his Pennsylvanian fireplace, as follows:

"1. A false back of four inch (or, in shallow small chimneys, two inch) brick work is to be made in the chimney, four inches or more from the true back; from the top of this false back a closing is to be made over to the breast of the chimney, that no air may pass into the chimney, but what goes under the false back, and up behind it.



Cross-Section of the Pennsylvanian Fireplace.

"2. Some bricks of the hearth are to be taken up, to form a hollow under the bottom plate; across which runs a thin, tight partition, to keep apart the air entering the hollow and the smoke; and is therefore placed between the air-hole and smoke-holes.

"3. A passage is made, communicating with the outward air, to introduce that air into the fore part of the hollow under the bottom plate, whence it may rise through the air-hole into the air-box.

"4. A passage is made from the back part of the hollow, communicating with the flue behind the false back: through this passage the smoke is to pass.

"The fire-place is to be erected upon these hollows, by putting all the plates in their places, and screwing them together.

"Its operation may be conceived by observing the plate entitled, Profile of the Chimney and Fire-Place.

M The mantle-piece, or breast of the chimney.
C The funnel.
B The false back and closing.
E True back of the chimney.
T Top of the fire-place.
F The front of it.
A The place where the fire is made.
D The air-box.
K The hole in the side-plate, through which the warmed air is discharged out of the air-box into the room.
H The hollow filled with fresh air, entering at the passage I, and ascending into the air-box through the air-hole in the bottom plate near
G The partition in the hollow to keep the air and smoke apart.
P The passage under the false back and part of the hearth for the smoke.

"The arrows show the course of the smoke.

"The fire being made at A, the flame and smoke will ascend and strike the top T, which will thereby receive a considerable heat. The smoke, finding no passage upwards, turns over the top of the air-box and descends between it and the back plate to the holes in the bottom plate, heating as it passes, both plates of the air-box, and the said back plate; the front plate, bottom and side plates are also heated at the same time. The smoke proceeds in the passage that leads it under and behind the false back and so rises into the chimney. The air of the room, warmed behind the back plate, and by the sides, front and top plates, becoming specifically lighter than the other air in the room, is obliged to rise; but the closure over the fire-place hindering it from going up the chimney, it is forced out into the room, rises by the mantle-piece to the ceiling, and spreads all over the top of the room, whence being crouded down gradually by the stream of newly-warmed air that follows and rises above it, the whole room becomes in a short time equally warmed.

"At the same time, the air warmed under the bottom plate, and in the air-box, rises and comes out of the holes in the side-plates, very swiftly, if the door of the room be shut, and joins its current with the stream before-mentioned, rising from the side, back and top plates.

"The air that enters the room through the air-box is fresh though warm; and, computing the swiftness of its motion with the areas of the holes, it is found that near ten barrels of fresh air are hourly introduced by the air-box; and by this means the air in the room is continually changed, and kept, at the same time, sweet and warm."

It is interesting to note the provision which is made for the chimney sweeps, as it will be remembered that the wood fuel which was commonly used at this time caused an immense amount of soot and tarry matter to deposit itself along the flues, which caused a diminution in draft or danger from fire when this carbonaceous matter ignited. Therefore, he makes provision for cleaning out back of his fireplace as follows:—

"A square opening for a trap-door should be left in the closing of the chimney, for the sweeper to go up; the door may be made of slate or tin, and commonly kept close shut, but so placed as that, turning up against the back of the chimney when open, it closes the vacancy behind the false back, and shoots the soot, that falls in sweeping, out upon the hearth. This trap-door is a very convenient thing."

We next come to a paragraph showing his wonderful conception of the requirements of ventilation as well as heating in connection with the use of his stove. We find in his statements the theories that are commonly accepted to-day, as will be seen in the following quotation:—

"In rooms where much smoking of tobacco is used, it is also convenient to have a small hole, about five or six inches square, cut near the ceiling through into the funnel: this hole must have a shutter, by which it may be closed or opened at pleasure. When open, there will be a strong draught of air through it into the chimney, which will presently carry off a cloud of smoke and keep the room clear; if the room be too hot likewise, it will carry off as much of the warm air as you please and then you may stop it entirely, or in part, as you think fit. By this means it is that the tobacco smoke does not descend among the heads of the company near the fire, as it must do before it can get into common chimneys."

It is interesting to note the trouble people had in keeping warm with the old-fashioned methods of heating which were in existence previous to the appearance of this Pennsylvanian fire-place. These points are well brought out in the description of the advantages of his fire-place, in which description he comments upon the short-comings of the other methods of heating.

"Its advantages above the common fire-places are,

"1. That your whole room is equally warmed, so that people need not croud so close round the fire, but may sit near the window, and have the benefit of the light for reading, writing, needlework, etc. They may sit with comfort in any part of the room, which is a very considerable advantage in a large family, where there must often be two fires kept, because all cannot conveniently come at one.

"2. If you sit near the fire, you have not that cold draught of uncomfortable air nipping your back and heels, as when before common fires, by which many catch cold, being scorched before, and, as it were, froze behind.

"3. If you sit against a crevice, there is not that sharp draught of cold air playing on you, as in rooms where there are fires in the common way; by which many catch cold, whence proceed coughs, catarrhs, tooth-achs, fevers, pleurisies, and many other diseases.

"4. In case of sickness, they make most excellent nursing rooms; as they constantly supply a sufficiency of fresh air, so warmed at the time as to be no way inconvenient or dangerous. A small one does well in a chamber, and the chimneys being fitted with it, it may be removed from one room to another, as occasion requires, and fixed in half an hour. The equal temper, too, and warmth of the air of the room, is thought to be particularly advantageous in some distempers."

The requirements in a stove or fireplace to enable one to start a fire, to extinguish it or to hold the fire in check so that it may smoulder slowly through the night, and be easily started the following morning, are shown in the provisions made by Dr. Franklin in his Pennsylvanian stove.

In examining the sectional view it must be understood that the upper front part of the stove opposite the letter F was only partially closed, while the lower part of the stove shown by the irregular line of moulding extending from the hearth, H, upward to the straight line, F, was simply an open space between the two sides of the stove, opening into the room and into this space the fire-dogs or andirons were placed when the fire was in operation. Under such conditions it is quite difficult to start a fire with a cold chimney, so Dr. Franklin provided an iron shutter which slides up and down the face, F, like a window shade, so as to partially or entirely close the opening into the room, and thus facilitate the handling of the fire, as stated by him, as follows:—

"A fire may be very speedily made in this fireplace by the help of the shutter, or trap-bellows, as aforesaid.

"A fire may be soon extinguished, by closing it with the shutter before, and turning the register behind, which will stifle it, and the brands will remain ready to rekindle.

"The room being once warm, the warmth may be retained in it all night.

"And lastly, the fire is so secured at night, that not one spark can fly out into the room to do damage.

"With all these conveniences, you do not lose the pleasing sight nor use of the fire, as in the Dutch stoves, but may boil the tea-kettle, warm the flat-irons, heat heaters, keep warm a dish of victuals by setting it on the top, &c."

We next come to a most interesting statement by Dr. Franklin which shows the prevailing idea concerning the prospects of obtaining coal for fuel in this country. At that time, the black stone, as it was called in England and Germany, had been dug from pits and was burned to comparatively poor advantage, but nevertheless giving off heat as it does, was recognized as a possible fuel of the future, and some of this pit coal (as it was called on account of the quarrying methods used for its removal to the earth) was brought over to America, but the idea that any of this wonderful substance could possibly be found in this country was very remote in the minds of those who gave the matter any consideration whatsoever. This is expressed by Dr. Franklin in the following paragraph, referring to countries in the north of Europe.

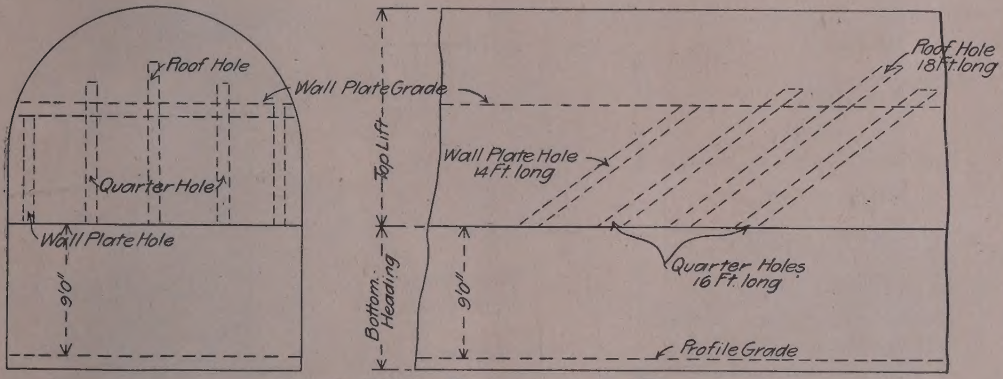
"The mentioning of those northern nations, puts me in mind of a considerable public advantage that may arise from the general use of these fireplaces. It is observable that though those countries have been well inhabited for many ages, wood is still their fuel, and yet at no very great price; which could not have been, if they had not universally used stoves, but consumed it as we do, in great quantities, by open fires. By the help of this saving invention our wood may grow as fast as we consume it, and our posterity may warm themselves at a moderate rate, without being obliged to fetch their fuel over the Atlantic; as, if pit-coal should not be here discovered (which is an uncertainty) they must necessarily do."

For Paint Shop Floors a recommendation was made at the last convention of the Master Car and Locomotive Painters' Association that cement and vitrified brick be used on account of freedom from dust, their cleanliness and low cost.

Construction of Indigo Tunnel, Western Maryland R. R.

A single-track tunnel, 4,332 ft. long, has recently been driven through Indigo Mountain on the extension of the Western Maryland R. R. in West Virginia and Maryland by taking out a bottom heading and then blasting out the remainder of the bore above this heading in a single lift. The railroad extension is 60 miles long, and follows in a general way the valley of the upper end of the Potomac River. The unusually heavy and difficult construction required to complete this extension was described in The Engineering Record for March 4, 1905. The Chesapeake & Ohio Canal parallels the river quite closely in the vicinity of the tunnel, having been built largely in a bench cut made in the precipitous rocky hills which rise directly from the water. The railroad has been built in a second bench cut in the rock above the canal. Indigo Mountain extends out beyond the remainder of the range on that side of the river, forming a long bend in the latter. The tunnel was driven to save upwards of 2 miles of extra distance and some difficult sidehill cutting that would have been necessary if the railroad had followed the river around the end of the mountain.

The tunnel was driven through very dense rock which did not require timbering as the work progressed. The tunnel extends nearly east and west, and is on a rising grade of 0.24 per cent. from the east, with 500 ft. of level grade in the middle, and a descending grade of 0.1 per cent. in the west end. The east portal is approached by a 6 deg., and the west portal by a 5 deg. curve, but the tunnel is all on tangent, except 150 ft. of easement curve at the east end and 30 ft. of easement curve at the west end. The standard required dimensions of the tunnel inside the timber lining were 14 ft. from the profile subgrade to the springing line of the arch, 17 ft. clear width below that line, with a rise of 8.5 ft. in the arch. In order to allow for the timbering the rock had to be removed for a width of 20 ft. 2 in. and a total height of 24 ft. 2 in. at the crown of the arch.



Method of Driving Blast Holes, Indigo Tunnel.

The method of driving the lower heading first and then taking the remainder of the tunnel above that in a single lift may be explained by reference to the accompanying illustrations. The grade of the tunnel at both ends was considerably above the bottom of the slopes of the mountain so that practically no approaches had to be cut before work could be commenced on headings. Construction was started on the west end of the tunnel in January, 1904, with the intention of driving a top heading and carrying the bench through with it in the usual manner. The top heading had been driven 176 ft. from that end before it was decided to drive the bottom heading. The bench of this top heading was then removed and 250 ft. of the bottom heading driven from the west end, beginning April 14. As the method of driving the bottom heading and then blowing down the roof was considered to embody a degree of uncertainty as to its feasibility, the top lift over this first 250 ft. of the bottom heading was taken out to demonstrate the practicability of the plan. A top heading was started in the east end about the same time work was commenced on the bottom heading in the west end, but was changed to a bottom heading in June after the completion of the 250 ft. of tunnel at the west end had shown the bottom heading to be feasible.

The usual intention was to make the bottom heading 9 ft. high and 20 ft. 2 in. wide, but the height varied from 8 to 10 ft. and the width was also greater in places than required, owing to the manner in which the rock broke out. The heading was shot with from 19 to 22 holes, placed as shown in the accompanying illustration. Cut holes were drilled 14 ft. deep and side holes 12 ft. These holes were loaded with an average of 175 lb. of 60 per cent. dynamite to each round of holes, with an average break of rock along the line of the tunnel of 10 ft. to each round. The holes were drilled, loaded and shot during an average shift of 8 hours. The number of men to a shift usually consisted of a heading foreman at $4.50 a day, 4 drill runners at $3.50, 4 helpers at $2.00, and one helper at $1.75. All drilling was done by a night shift and the loosened material removed during the day. The gang required in removing the loosened material consisted of a foreman at $3.00 a day and 10 "muckers" at $1.75, who would remove in 8 or 9 hours the material loosened during the night shift. While the headings were being driven the loosened rock was removed in dump cars which were hauled to the portals on narrow-gauge tracks by mules. The night shift was always able to finish the drilling and blasting so the day shift could go on at 7 o'clock in the morning, except on one occasion when unusually hard rock was encountered and two shifts were lost, 18 to 20 hours being required to drill the holes and shoot them.

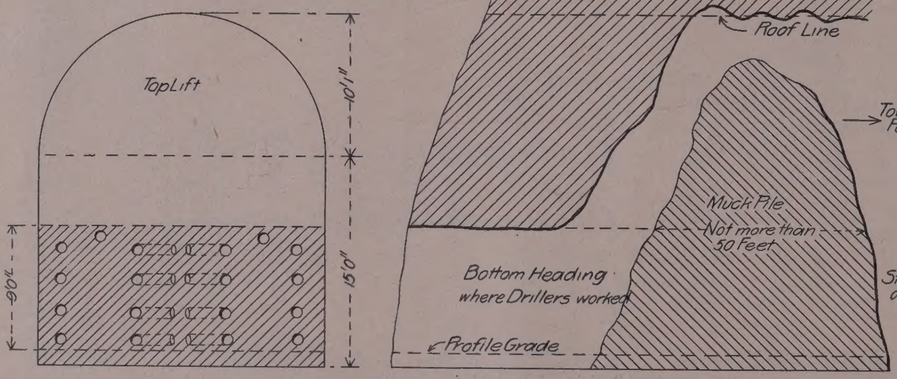
The bottom headings from the two ends had met and been cleaned out ready for the com- of the top lift on March 13, 1905. When the headings met the alignment was practically perfect, the elevations checked to 0.03 ft. and the mencement of work on the drilling and blasting measurement to 1.2 ft. The drilling and blasting of the top lift was carried on from both ends of the tunnel, and after March 13 this work was done by a single shift at each end. The arrangement and spacing of the blast holes for the top lift are also shown in one of the accompanying illustrations. Not more than 6 holes nor less than 4 were used to the round at any time. All the holes were driven on an angle of about 35 deg. with the horizontal, slanting away from the portal. A roof hole, 18 ft. long, was placed on the center line, with a quarter hole, 16 ft. long, on each side of it, and side holes, 14 ft. long, or to wall-plate grade. An average of 50 lb. of dynamite was used to each round of holes for loosening the roof, a breast of 10 ft. being broken out by this amount.

A model "20" Marion steam shovel was installed in the east end and a model "C" Marion steam shovel in the west end on March 19. Both shovels were operated by compressed air and one was placed on the side toward the portal of the pile of muck at each end loosened by the blasts in the roof. They were operated night and day, except Sundays, until the tunnel was completed. The material handled by the shovel in the west end was hauled to the portal in twelve 3-yd. dump cars by a small locomotive; 4 mules with the same number of cars served the other shovel. The drillers worked in the bottom heading just in front of the muck pile, the same number of men being required to do this drilling and blasting in the top lift that was necessary in the bottom heading. Owing to the difficulty of getting supplies and drills to the drillers not more than 50 ft. of the roof was shot down at a time.

The drilling and blasting of the roof was finished June 16, 2 months and 3 days after that work was commenced. The tunnel was completed June 29. From August, 1904, to the completion of the work in June, about 10 months, 3,800 ft. of the completed tunnel was driven through solid rock. During the month of June 1,269 ft. of the top lift was removed by the two shovels, the model "20" shovel handling the material from 813 ft. and the model "C" handling that from 436 ft. Very little difficulty was experienced in keeping to grade in the roof, but it was found necessary to keep one drill on top of the muck pile to trim the roof arch to proper shape. After the shovels were taken out some trimming was also found necessary, but this was very successfully and economically done from scaffold cars with small drills mounted on tripods. All the material from the trimming was used for packing back of the timbering as the latter progressed.

Standard Ingersoll-Sergeant rock drills, operated by compressed air at pressure of from 80 to 100 lb. per square inch, were used in making all of the blast holes. A compressor plant containing two 24x30-in. Ingersoll-Sergeant compressors was installed near the west portal and supplied power to run the drills and the steam shovels. A 6-in. pipe line, 6,700 ft. long, was laid over the top of the mountain to carry the air to the machines at work in the east end. A Wagner electric generator in the compressor plant furnished power for lighting the tunnel at all times and the outside work at night. Ventilation was secured by a No. 8 Sturtevant exhauster near each portal connected to a line of 14-in. spirally-riveted steel pipe laid in the tunnel to the point where the work was in progress.

The face of the mountain was very steep at both portals and considerable difficulty was experienced in disposing of the rock removed from the tunnel. The east portal was also almost directly over the canal and was separated from the steep side hills, parallel to the latter a little farther beyond, by a deep narrow gulch. The bench for the track could not be cut through until the canal could be closed, so the only way to handle the rock from this end of the tunnel was to haul it up the gulch. The bottom of the gulch rose on a slope of 20 ft. to the 100 ft. and in order to provide room for the material a narrow-gauge double-track tramway was built up the gulch, after the space immediately in front of the portal had been filled to grade. Two Lidgerwood hoisting engines were set up on a level place about 500 ft. up the gulch from the portal and hauled the cars up the tramway to a dump. A similar arrangement was also required in a gulch at the west end on the early work carried on from the west portal, but later the material from that end was utilized in making a fill above the canal.



Excavation Sequence in Indigo Tunnel.

The extension of the Western Maryland R. R. was built under the direction of Mr. J. Q. Barlow, chief engineer. The tunnel was driven and about 80 per cent. of the work on the extension done by the MacArthur Bros. Co., of Chicago, and the Kilpatrick Bros. & Collins Co., of Omaha, Neb. Mr. M. H. Keefe, as superintendent for the contractors, devised the method of driving the bottom heading and completed 530 ft. of the tunnel. Mr. Patrick Ford succeeded Mr. Keefe and carried the work to the completion. Mr. Preston Bowles was immediately in charge of the section of the construction including the tunnel for the railroad company.

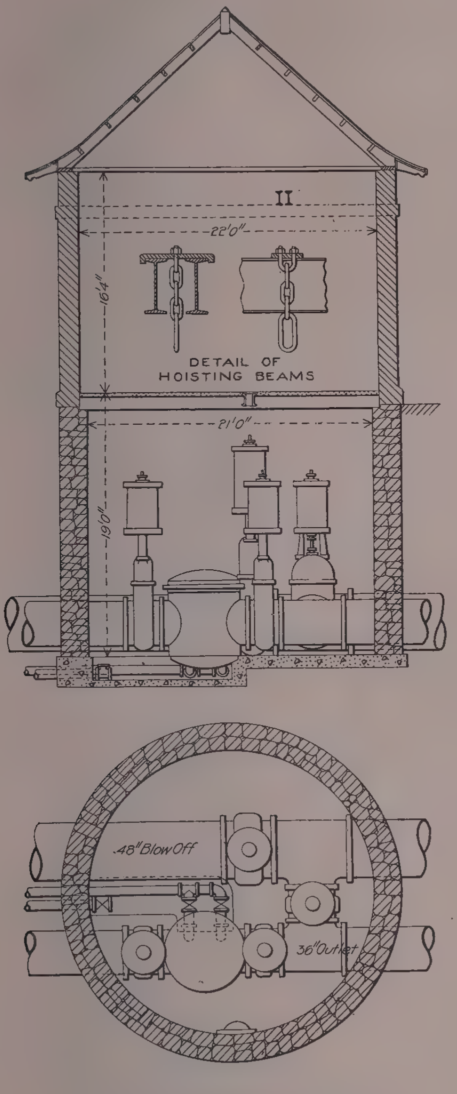
The Indian Creek Dam.

The Mountain Water Supply Co. of Connellsville, Pa., has recently completed a reservoir which will impound the run-off from an area of 109.6 sq. miles of the catchment basin of Indian Creek. This reservoir has a capacity of 230,000,000 gal. and has been built by the American Pipe Mfg. Co., of Philadelphia, from plans prepared by its engineering department, headed by the chief engineer, Mr. J. W. Ledoux. The dam is a masonry structure of the cross section shown in the accompanying illustrations. It is about 650 ft. long and its central portion for a length of 300 ft. serves as a waste weir, the crest of the weir being 6 ft. below the crest of the adjoining portions of the dam.

The structure has a face on either side of rather hard sandstone ashlar, averaging about 3 ft. in thickness. Between the faces 1:3:5 Portland cement concrete is used as a hearting, with about 25 per cent. of its volume consisting of boulders. Giant Portland cement was used, the sand was procured by crushing the local sandstone, and the broken stone was 1½ in. in size. The concrete was prepared in Smith mixers and deposited in 6-in. layers wet enough to be packed readily. Each finished layer of concrete was grouted with liquid neat cement before the next layer was deposited.

The gate house and its valves are shown in one of the illustrations. It will be noticed that this gate house differs very materially from the customary design, having vertical screens. The circular plan of the house reduces the amount of masonry to a minimum and the reinforced concrete floor, consisting of 4 in. of concrete on expanded metal, the whole carried on 12-in. I-beams on 4-ft. centers, is a cheap and reliable form of construction. The blow-off pipe is 48 in. in diameter while the outlet pipe is but 36 in. In the latter is placed a steel screen-pot with a 6-in. blow-off pipe for removing the sediment that may collect on the screens. There is also a drain pipe through which the gate house can be drained; at its upper end, within the gate chamber, there is a check valve preventing any water from entering the chamber. At the upstream face of the dam the ends of the blow-off and outlet pipes are closed by sluice gates which are protected by racks permanently attached to the face of the masonry. These sluice gates are operated by standards on the top of the dam. The gates in the gate house are all operated by hydraulic valves, with the exception of the small ones on the blow-off pipe of the screen-pot.

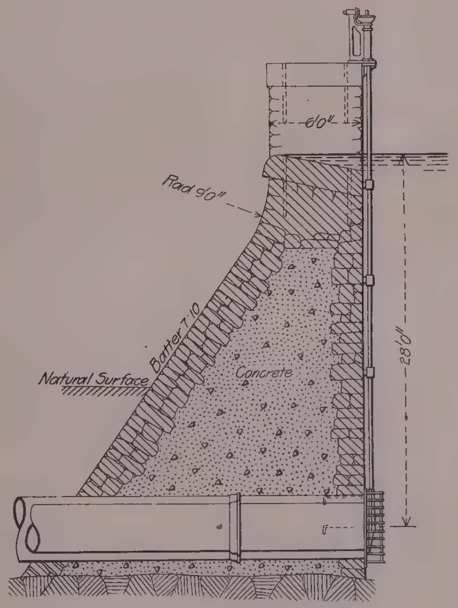
It may be recalled by some readers that newspaper reports said that this dam had given way about a couple of months ago. Nothing of the sort had happened. When cold weather set in three slight transverse cracks developed, as had been expected by the engineers. These caused no apprehension because the foundation is solid rock for the entire length of the dam and the cross section of the latter is a very heavy gravity section. In some of the dams designed by the American Pipe Mfg. Co. an attempt has been made to prevent these temperature cracks by reinforcing the concrete with various types of steel bars, but in the proportions recommended for their use by the makers they have not been found adequate for the purpose. Accordingly no reinforcement was used in the Indian Creek dam. Mr. Ledoux states that the cracks which result from temperature changes soon fill up with a kind of efflorescence from the cement and will hardly be discernible by the following summer. The largest crack on the Indian Creek dam was a little less than 1/16 in. in width. The level of the dam did not change at all, but the cracks went through from face to face and from top to bottom. They follow the joints as a rule but in some cases break through stones 3 ft. thick. It has been suggested that as the temperature changes occur only near the surface of the masonry if sufficient steel reinforcement were provided to prevent these surface cracks the masonry would not crack as a whole. The experience of the American Pipe Mfg. Co. is at variance with this idea, for wherever the masonry of any of the numerous dams built under their direction has cracked, the crack has been completely through the body, and although it would appear improbable that a thick mass of masonry should change in temperature all at the same time, the results are as stated.



Gate House, Indian Creek Reservoir.

Present Practice in Sewage Disposal.

At the recent meeting of the New Jersey Sanitary Association, Mr. George W. Fuller, of New York, read a paper summarizing in an interesting manner the present practice in sewage disposal and indicating some of its most important tendencies. The first feature he mentioned was shellfish pollution. The Royal Commission on Sewage Disposal for Great Britain issued a report some eighteen or twenty months ago devoted to the infection of shellfish, to the pollution of seacoast water and to the life of disease germs, such as typhoid fever, in shellfish and in coast waters. In London and Manchester it has been concluded after careful investigations that about 8 to 10 per cent. of all typhoid fever in those cities has for some years been caused by infected shellfish. In several seaport towns the proportion has reached over 50 per cent. Although a commission has been working on this subject for several years, many practical features are still unsolved. These unsolved problems relate especially to those cases where the pollution is slight or occurring only at intervals. Where the pollution is excessive or absent, the treatment is obviously simple. Mr. Fuller also called attention to the work conducted by the Massachusetts State Board of Health during the past two or three years with reference to shellfish and sewage disposal, especially on the seacoast. On this subject the recent Massachusetts reports contain most valuable evidence.



Section of Indian Creek Dam.

In regard to disposal along seaport towns, there is necessity of improvement in the majority of instances. With few exceptions the sewage is disposed of by dilution. It is conveyed to bodies of salt water, such as tidal streams or bays or other arms of the sea. This method of disposal in a majority of instances, when well carried out, has been found to be reasonably satisfactory from the standpoint of avoiding general nuisances. It is capable of being better applied in many instances, not only along the Massachusetts seacoast but along the entire Atlantic coast. One of the least satisfactory features in the disposal of sewage by dilution is that the sewage is not brought quickly enough to the deep water where adequate currents exist to disperse the sewage. There is a tendency in many places to allow the outfall sewers to stop on the flats exposed at low tide, or in shallow water, rather than to convey the sewage to deep water where the outlets are suitably located and submerged at all times. The method of disposal by dilution has, of course, a different phase when it involves the pollution of shellfish, which makes it a proposition requiring special consideration. This method of disposal is not such a barbarous practice from the standpoint of eliminating nuisances as one might imagine, when compared with the disposal of garbage and with the ventilation of public and private dwellings.

In the disposal of sewage by dilution it is necessary, as already stated, to see that the sewage is thoroughly and quickly dispersed throughout the body of water in which it is diluted. It is probable that the portion of New York City on Manhattan Island is the best located city in the world for the disposal of sewage by dilution. That does not mean necessarily that it is perfect, but by extending the sewers out to or beyond the pier lines, and having the sewage discharged well beneath the surface of the water after screening from it all coarse, solid particles, there results a method of disposal probably unsurpassed both in regard to cheapness and to lack of offensiveness.

Where the question of shellfish is not a factor, dilution will no doubt continue for many years to be the most prevalent method of disposal. It is obvious from available evidence that there is much room for improvement at present, and that current practice will be much modified. With the removal of suspended particles of visible size, there are still left for consideration in large projects the questions of odors and of sleek, which is the thin film of grease upon the surface of the water in the vicinity of the outfall. As the volume of sewage discharged at a single point increases, the importance of these factors also increases. How much sewage can be discharged through a single outfall is still a more or less debatable question. At the Deer Island outlet in Boston Harbor about 50,000,000 gals. of sewage are discharged daily. Odors are rarely if ever noticed at a greater distance than one-quarter of a mile, which is generally stated as the limit to which odors can be detected in the neighborhood of large modern purification works in Europe. The sleek on the surface of the water in calm weather can be seen for a mile or so. Means for the removal of the grease producing this sleek, and for aerating the sewage to reduce odors, where these factors are objected to, are fruitful fields of investigation. Their accomplishment will no doubt be very much less expensive than that for complete purification.

Where shellfish is found in seacoast waters, the sewage of neighboring cities should be disposed of according to the relative financial importance of the shellfish industry and of the purification of the sewage. Where the oysters and clams represent relatively small sums of money, then purification works will presumably not be built; the shellfish will be eliminated and the sewage disposed of by dilution. Where the shellfish industry is large and the necessary sewage works comparatively small and inexpensive, the logical thing to do is to purify the sewage thoroughly in artificial works along the lines required of inland cities where the quality of neighboring water supplies is a factor. There is also, of course, an intermediate class where local conditions must be most carefully studied before deciding between the shellfish and purification works.

The first method for the artificial treatment of sewage mentioned by Mr. Fuller was sedimentation, which is simply allowing the sewage to flow through shallow reservoirs, holding ordinarily from two to twelve hours' flow. In these basins are deposited from 50 per cent. to 70 per cent. of the coarser suspended matters, and about the same per cent. of bacteria. Sewage purification by sedimentation is perhaps a misleading statement, for it is not purification in the full sense of the word. It is more properly clarification, in which there is a removal of some of the sludge or suspended matter. This is a reasonable thing to do, as it reduces clogging of the filter in which the sewage is finally purified.

The last few years have brought to the front the correct idea that sedimentation and allied methods are really preparatory treatments, and that they do not constitute by themselves a full purification process. Sedimentation is very similar to chemical precipitation, which is practiced in a few places in this country and in many European places, except that efficient works of the latter type reduce the suspended matter and bacteria 80 to 90 per cent. Septic treatment, so-called, is nothing more or less than plain sedimentation to which is added the practice of not removing sludge, but allowing the latter to remain for a long time on the bottom of the reservoir holding at least eight hours' flow, and to rot there. The rotting is nothing more than putrefaction by bacterial agencies. This putrefaction causes on an average about one-half of the total matter deposited from the sewage to become liquefied and gasified. In that way the septic tank is a helpful preparatory step, as it puts the sewage in shape to be treated by some method of filtration more advantageously, and reduces the cost of sludge disposal.

The total organic matters in sewage are reduced about one-third by sedimentation and by the septic treatment, and about one-half by chemical precipitation. Effluents of all of these treatments are putrescible, and, as above stated, require subsequent filtration ordinarily, although there are cases, apparently, where any one of these preparatory treatments may suffice for the present in eliminating nuisances.

Intermittent filtration through sand is well known through the Lawrence investigations and the fifteen to twenty plants where this method is practiced in New England. Coarse-grain filters have been developed largely in New England, although they have been studied carefully at Lawrence and elsewhere in this country, and also in Germany. These filters, known as contact filters or sprinkling filters, according to the method of operation, have made a marked advance in matters of sewage purification, especially for cities not having near at hand suitable areas of porous sand.

For cities of small or moderate size, where medium or coarse sand is readily found, the best method of purification is ordinarily intermittent sand filtration where an effluent of high bacterial purity is necessary or desirable. Where the filters are not overcrowded, the resulting effluents are practically clear, odorless, and contain only about 1 per cent. of the applied bacteria. The organic matter in the sewage is reduced much below that necessary to secure a non-putrescible effluent. One acre of land disposes of the sewage of from 500 to 1,000 persons, depending upon the porosity of the sand, care of filters, preliminary treatment of sewage, etc. Higher rates can be used, but it means more care and expense in keeping the filter surface free from clogging in winter work. Experience has shown that intermittent sand filtration is much more expensive than was thought to be the case some years ago. In fact, the experience of the last ten years in Massachusetts (see 1903 report of State Board of Health) with sand filters shows that the cost of these filters approximates, on an average, about 43 cents per capita per annum, divided about equally between capital charges (5 per cent. per annum) and maintenance. This cost has nothing whatever to do with the collection system of sewers in the city, nor with the conveyance or pumping the sewage to the disposal works. It is solely for the purification of the sewage.

Where an effluent of high bacterial purity is not necessary, coarse-grain filters give adequate results so far as a non-putrescible effluent is concerned. These filters are cheaper than intermittent sand filters where suitable sand is not readily available, and apparently in some cases also where such sand is found in the vicinity. The latter instances refer especially to conditions where the cost of delivery of sewage to intermittent filters much exceeds that for coarse-grain filters.

One of the most important conclusions to which one is led by recent evidence from this country and abroad is that coarse-grain filters have a field of usefulness where high bacterial efficiency is required. Contact filters, or sprinkling filters, are perfectly capable in connection with a suitable preparatory treatment of producing a non-putrescible effluent containing about 50 parts per million of suspended matter, and about 10 per cent. of the bacteria in the raw sewage. Such a liquid is comparable with a turbid river water which is highly polluted with sewage. In other words, coarse-grain filters reduce a sewage to a state where it can be subjected to the treatment applied for the purification of drinking water from turbid and polluted rivers. Mechanical filtration along the lines carefully worked out during the past ten years is perfectly capable of converting the effluent of coarse-grain filters to a state of bacterial purity fully equal to that obtained by intermittent sand filters. This combined treatment is apparently cheaper than intermittent sand filtration for large projects, even where sand is fairly accessible; for small plants there is probably no economy. Where the dividing line comes in, conditions favoring one or the other of these methods of purification can hardly be stated at present. It is a topic, however, upon which much will be said in future.

The application of copper sulphate or other germicides to the effluent of coarse-grain filters is another way of securing a final product of high bacterial purity. It is probably more expensive and no more effective than a final filtration as above mentioned. For small plants it is nevertheless of value.

Preparatory treatment of the raw sewage to remove the sludge is highly desirable for nearly all large projects, Mr. Fuller said. For small ones it is not necessary where the sewage is treated by sand filters or sprinkling filters. Contact filters under all circumstances are operated to better advantage with a clarified sewage. Septic tanks are the best preparatory devices for ordinary conditions.

All of these remarks are directed to domestic sewage containing only small or moderate amounts of trade wastes. Large quantities of trade wastes increase the difficulty and expense of purification very materially. Trade wastes vary so in their character that each case requires special consideration, and there is very little to be said in general terms.

As to the capacity and best type of coarse-grain filters, much evidence is available from abroad where such filters have been operated on a practical scale for six or eight years. Valuable data have also been obtained in this country, both in practice and from test devices. The strength of sewage, climatic conditions, etc., are so different in America that foreign data are of less specific value for use in this country than are those obtained here. The city of Columbus, Ohio, has, in particular, secured valuable data on recent methods of sewage purification, and data which are of value for application also along the seacoast.

Coarse-grain filters of all types should consist of firm material which will not disintegrate. Ordinarily the filters are 3 to 5 ft. thick; sometimes sprinkling filters are 8 ft. thick. All filters should be well under-drained. Contact filters are operated on the fill and draw plan. Sprinkling filters have the sewage applied to them in the form of a spray, either from revolving perforated pipes or from stationary pipes with nozzles. Contact filter material usually ranges in size from ⅛ to 1 in. and that for sprinkling filters from ½ to 2 in.

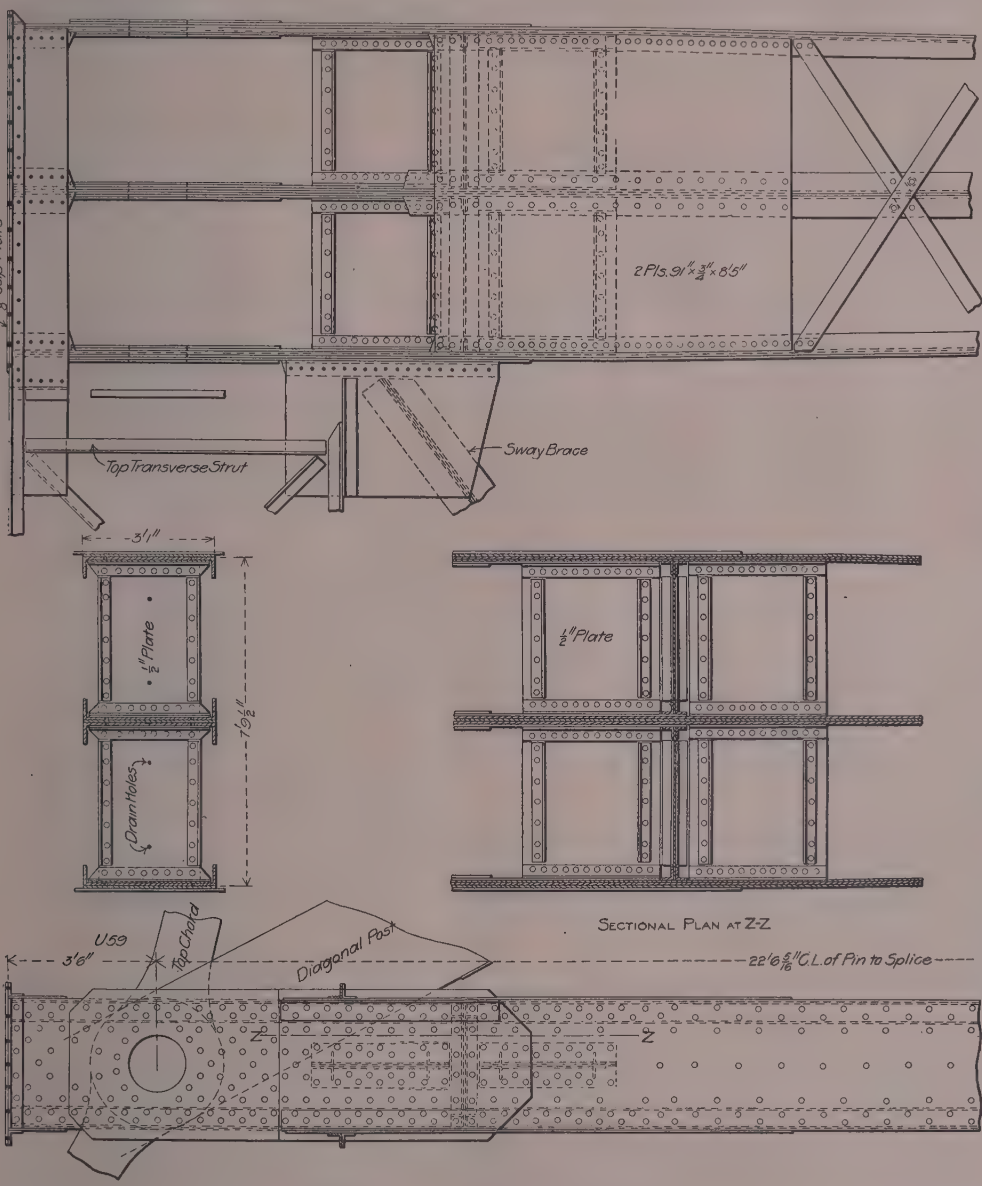
The city of Columbus, Ohio, voted two years ago to spend $1,200,000 in improving their sewerage system, including purification works. To determine the best method of securing a non-putrescible effluent at least cost it was decided to devote $46,000, or approximately the interest for one year, to a series of tests of the local sewage. The testing station was commenced a year and a half ago and was conducted for a period of one year. The results accomplished there are now in final shape, and are being printed in a public document which will probably be available in a few months. These tests at Columbus show the results accomplished by more than forty different devices in various combinations. The relative amounts of sludge, organic matter and bacteria which are removed by different methods of preliminary treatment were ascertained. They also furnish a large range of data as to the best rates, kinds and grades of material, etc., for filtration.

In brief, it was found that the best preparatory treatment was afforded by septic tanks holding an average flow of about eight hours. This caused a removal of about two-thirds of the bacteria and suspended matter in the sewage. About one-half of the deposited sludge is liquified and gasified. No trouble with odors was encountered. Sprinkling filters operated at an average rate of 2,000,000 gals. per acre daily form the next step in the process. It was found that winter weather, even in the severe climate of Columbus, did not seriously interfere with spraying the sewage on the filters. A non-putrescible effluent was obtained, containing about 10 per cent. of the original bacteria. Contact filters could produce an equal result when operated only at about one-fourth to one-third of the above stated rate for sprinkling filters. Further, there is less clogging in sprinkling filters than in contact filters, due to the suspended matter retained as films within the sprinkling filter cracking and peeling when the filter is rested (every other week). This removal of stored suspended matter is one of the chief characteristics of sprinkling filters. It makes the effluent somewhat unsightly in appearance, Mr. Fuller said, but this is readily corrected by passing the effluent through a small settling basin holding two or three hours' flow. A 20,000,000-gal. plant of this type (see Eng. Rec. Dec. 30, 1905), was recently put under contract at Columbus for $435,000, exclusive of land and of force mains and pumping station for delivering the sewage to the works.

Waterproofing Operations on a reservoir in Galatz, Roumania, are described in a paper by Mr. W. M. Langford, published by the Institution of Civil Engineers. The reservoir consists of two basins 95 ft. long, 74 ft. wide and 13 ft. deep, with concrete floors 2 ft. 2 in. thick, rubble masonry walls and brick arched roofs supported on brick piers. The structure rested on a foundation that was entirely stable when dry, but settled and increased the leakage when wet by percolation through the masonry. It was accordingly attached to the walls by tie bolts and a course of expanded metal, which not only held the waterproofing in place, but also served as lathing for a finishing coat of cement rendering. There are 96 piers in the two basins, and each of there was underpinned, its footing cut out and bitumen sheeting placed below it. The footing was then rebuilt, leaving the sheeting projecting about 12 in. on each side, so it could be jointed to the floor sheeting laid subsequently. The work was done without permitting any settlement of the roof arches and both basins were made quite watertight.

Main Vertical and Inclined Posts, Island Span, Blackwell's Island Bridge.

The 630-ft. island span of the Blackwell's Island bridge connects the cantilever arms of adjacent 1,182-ft. and 984-ft. river spans and has two pin-connected trusses 60 ft. apart, with a minimum depth of 118 ft. on centers and a height of about 120 ft. above the ground. It weighs about 22,700,000 lb., exclusive of towers, of which about 11,000,000 lb. is for the two decks carrying the roadways, sidewalks and eight lines of railroad and street car tracks. Some of the truss members are very long and massive, and the heaviest piece lifted by the traveler weighs about 80 tons. The lower parts of the trusses and the upper and lower roadway decks are now being erected on steel falsework by two sets of very powerful steel travelers moving on the upper floor.



Upper Part of Vertical Post L59 U59.

The heaviest complete members are the 240,000-lb. lower-chord sections, but they are not so long as the 200-ft. first diagonal posts, L59-U57, which have a sectional area of about 400 sq. in. and weigh about 298,000 lb. These and all the main vertical and diagonal members are made in two lengths, pin-connected together at the middle of the height of the truss. Like the chords, which were described in The Engineering Record of Jan. 6, these diagonal posts have four webs shop-riveted in pairs, and the pairs, which form longitudinal halves of the half-length pieces, were designed to be field-riveted together, thus reducing the separate pieces to weights which could easily be handled at the shops, shipped on cars and assembled in erection. For practical considerations it was finally decided to shop-rivet the longitudinal splices and the 169,000-lb. pieces 105 ft. long have been successfully shipped and erected.

The upper part of the post has maximum tensile and compressive stresses of +2,050,000 lb. and —4,370,000 lb., respectively, and a cross-section of 365 sq. in. The lower part of the member has stresses of +1,400,000 lb. and —4,840,000 lb., and has a cross-section of 400 sq. in. It has a width of 3 ft. 3½ in., a depth of 3 ft. 7 in., and a radius of gyration of 12.8 in. Each outside web is made of two 42½x¾-in. plates, one 30x¾-in. plate and two 6x4x¾-in. flange angles. The inner ribs are of similar materials and all of them are made in lengths of about 50 ft., shop-spliced with cover plates to make a length of 100 ft. 9 15/32 in. on centers of pins.

The webs and flange angles are riveted up to make great built channels, and the pairs of these that are shop-riveted to make the halves of the post sections are connected by lattice bars and tie plates on both flanges and by four transverse diaphragms, made of four 3½x3½-in. angles and a 7½x½-in. plate. The two halves are connected by field-riveted narrow lattice bars on both flanges and by the tie plates riveted at the ends of the member to the flange angles and at the intermediate splice to special short connection angles on the sides of the web opposite the flange angles. Near each end the pairs of webs are stiffened by diaphragms parallel with the flange angles, which are on the center lines of the webs and extend to the end transverse webs. These two sets of webs are intended to prevent twisting of the member due to stresses developed in shop-riveting and other manufacturing processes, and give the member great rigidity.

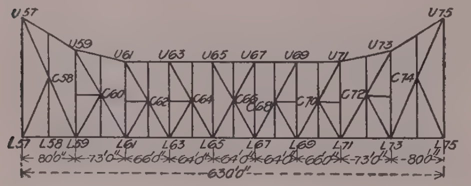
Both ends of each web are reinforced by single pin plates, which, with the other plates, provide total lengths of about 11 in. for the bearings of the 16½-in. pins. Four duplicates of this member are required, two of them marked L59-C58 and two are marked L59-C58a. The upper parts of the same members are similar and the other principal diagonal posts correspond.

The center panel diagonals, L67-U69, are 136 ft. long, have maximum stresses of —282,000 lb. and +2,460,000 lb., a cross-section of 212 sq. in., a radius of gyration of 10 in., and are completely shop-riveted. The upper and lower parts are substantially alike, and are 30 in. deep by 36 in. wide; each is about 67 ft. long. The lower end is connected to the bottom chord by a 14¼-in. pin, and the upper end is pin-connected to the top chord. At the center both pieces are field-riveted to the vertical member of the truss at its intersection. Each section weighs about 60,000 lb. and is made, as shown for the lower one, of two built channels latticed, and connected by lattice bars and by four transverse ½-in. diaphragms. Each channel has a 30x⅞-in. and a 28x¾-in. web plate and two 6x6x13/16-in. flange angles.

Post L59-U59 is typical of the vertical posts at the main panel points, and is the largest and heaviest of them. It has a maximum stress of 5,510,000 lb., a cross-section of 281 sq. in., a radius of gyration of 12 in., a length of 135 ft., and weighs about 220,000 lb. It is made in an upper and a lower section, pin-connected at a point 67 ft. 5¾ in. above the bottom chord pin. It has three 37-in. webs, spaced to clear the four bottom chord webs; each section has a full-width plate, two 6x6-in. flange angles and a reinforcement plate between the flange angles. At the foot of the post the webs are additionally reinforced with nickel-steel plates, and the one on the inside of the post is field-riveted to the main floorbeam, which has an end reaction of 288,000 lb. To carry this load there are 34 1-in. field rivets at each end. The outside floorbeam bracket is 13 ft. long with a maximum load of 77,600 lb., and its end web-connection rivets are supplemented by 13x½-in. horizontal bars, passing through slots in the three post webs and engaging the top flanges of the main floorbeam and of its cantilever projection outside the truss, which carries two lines of street car tracks.

The lower section of the post is 71 ft. 6¾ in. long over all and weighs about 103,000 lb. Its webs are shop-spliced with a milled joint and pairs of 12-in. cover plates at a point 22 ft. 7¼ in. below the upper pin at C59. Between this splice and the main floorbeam, the three webs are connected by a vertical transverse diaphragm on the center line about 24 ft. long. This is made in two I-shaped pieces, each composed of a 24x½-in. web and four 6x4x½-in. angles, which thus add about 60 sq. in. to the effective cross-section of the post. Where the three main longitudinal webs of the post are reinforced it is necessary to offset the flange angles of the transverse webs or diaphragms to clear them, and at these points they are cut and spliced and the gauge is changed. About 27 ft. above the lower chord pin there is shop-riveted to the outer face of the post a seat for the field-riveted connection of a cantilever sidewalk bracket 3 ft. long. The seat is a T-shaped projection made of a 10x⅜-in. web plate and two full-length 6x4-in. flange-connection angles. At the upper end there are six web holes for field rivets to resist tension by double shear, and at the lower end there is a pair of 5x3½-in. outer flange angles about 3½ ft. long, which provide an abutting surface for the end of the bracket and are connected to it with 16 field rivets.

Opposite the sidewalk bracket, on the inner face of the post, there are 92 field rivets through the web and diaphragm flange angles for the connection of the upper-deck floorbeam and knee-braces. About 18 ft. below the center of the upper pin, two 58x⅝x7-ft. 10-in. tie plates are shop-riveted across the channel flanges, projecting beyond the inner face of the post to form jaws with field-riveted connections for the lower transverse strut and sway-brace diagonal. At this point, at both ends, and at two intermediate points, the post webs are connected by wide tie plates across their flanges; between these plates the flange angles are latticed with 5x7/16-in. bars intersecting on the center web and having two rivets there and two at each end. At the upper end, near pin C59, the webs are connected by a horizontal diaphragm and are reinforced by several thicknesses of short plates, which give a combined length of 17 in. for the bearing of the 16½-in. pin. About the same bearing is provided for the bottom-chord pin, L59.



Island Span.

The upper portion of the post, C59-U59, is about 73 ft. long over all and weighs about 116,000 lb. It has three longitudinal webs corresponding to those of the lower portion, and at C59 they are spaced 2 ft. apart to match the latter, but the outer ones diverge upwards to a spacing of 7 ft. 9½ in. apart at a point about 7 ft. below the center of the top-chord pin, U59, where they are connected by both vertical and horizontal transverse diaphragms. At this point the webs are also connected by a pair of 91x¾x8-ft. 5-in. flange cover plates, and the post is thus made very rigid to receive and distribute through its three webs the stresses from the top lateral system, the upper transverse strut and the sway brace diagonal, which are field-riveted to the inner web. The webs are heavily reinforced for the bearing of the top chord pin, U59, and extend 3½ ft. above its center, where they are capped with a ⅝-in. horizontal plate. The webs are each shop spliced with four ½-in. cover plates, 4 ft. 7 in. long, at a point 22½ ft. from the center of the top-chord pin, and are connected by flange tie plates and by lattice bars like those in the bottom section of the post. Just above pin C59 the webs are connected by longitudinal and horizontal diaphragms, the former being about 9 ft. long.

The design and erection of the bridge is under the direction of the Department of Bridges, New York, Mr. James W. Stevenson commissioner, Mr. O. F. Nichols chief engineer, Mr. R. S. Buck consulting engineer, and Mr J. D. Wilkens engineer in charge The contract for the manufacture and erection of the superstructure was awarded to the Pennsylvania Steel Co. The details of the superstructure for the island span have been illustrated in The Engineering Record of March 4, May 20, 27, and June 10, 1905, and Jan. 6, 1906.

WATER SOFTENING on two large Western railroads during the past year is said to have increased the life of boiler tubes from three to five times and reduced boiler repairs by 30 to 50 per cent.

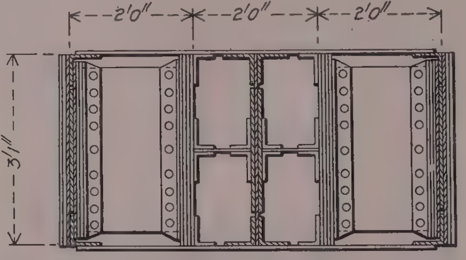
Government Contracts: Legal Pitfalls and How to Avoid Them.—VII.

By George A. and William B. King, Members of the Bar of the Court of Claims.

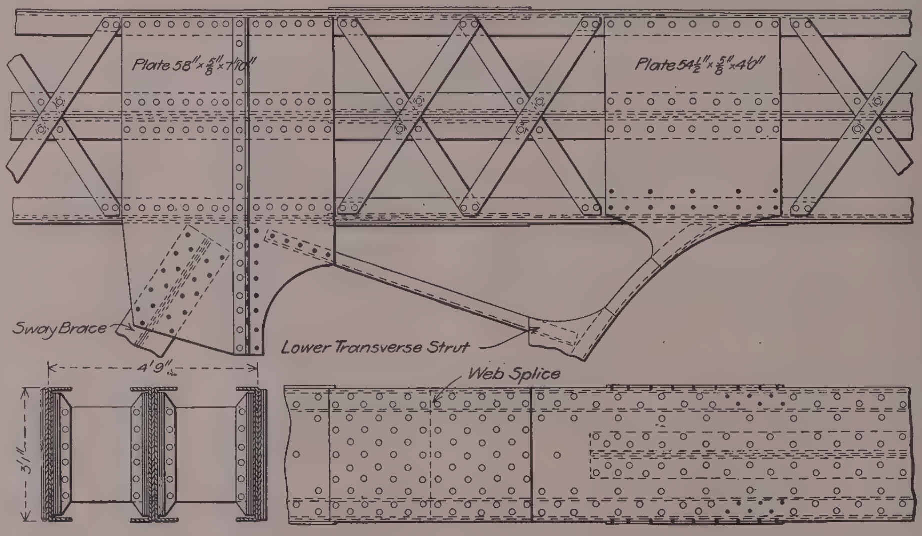
Preserving the Contractor's Rights.—The preceding chapters have defined what the law regards as remediable wrongs to contractors, caused by the engineer's or inspector's arbitrary exercise of power, by improper interference with the contractor's work, by the government's delays or by the enforcement of unauthorized alterations or of extra work.

What must the contractor do for his own protection, when such wrong is done him, to preserve his right to redress in court? Unless he is mindful of his course, he may be accused of acquiescing in the wrong done him or he may make errors which will put him partly at fault. The decisions of the Supreme Court and the Court of Claims will show him what he must do.

Protest Required.—First of all, a contractor must make known to the proper governmental authority his belief that wrong has been done him, for which he expects to be recompensed. He must not permit the officers of the government to have any question about his own position. If he does not affirmatively show his objection to the violation of his rights, he may find himself in the end deprived of any right to recompense. No particular form of protest or notice is necessary, so long as his position is made known. Numerous illustrations of this occur in cases already cited in this discussion.



Cross Section of Upper Part of Vertical Post L59 U59.



Middle Part of Lower Section of Vertical Post L59 U59

Under the contract made in 1874 for constructing a breakwater at Sand Beach, Michigan, a reduction was made in the size of the cribs, for which the contractor claimed his lost profits. The court did not even consider the loss of profits because the contractor acquiesced in the change, purchased his material to suit the changed plan and "constructed the cribs without protest and without expression of dissent." The height of the superstructure over the shore breakwater was reduced after he had purchased his materials and the contractor, the court said, "received a less sum than he would have received if no change had been made." In this he suffered an undoubted loss, but the court adds that he accepted it without objection and without notice of his loss and the change must be regarded as "made without the assent of the claimant."

Certain contractors were building ironclads for the government during the Civil War when prices were rising rapidly. The government suspended the work, the result being to throw much of it into a period of higher prices. The court said that "the claimants neither protested against nor objected to the suspension of the work so ordered nor notified the government that damage would result to them thereby." Upon this condition of facts, it treated them as acquiescing in the delay and waiving any right to claim.

In the claim for damages under the contract at the Cross Ledge Shoal Lighthouse a delay on the part of the government was alleged as a ground of claim. The court said that if delay were proved "the claimant could not demand damages therefor since he made no complaint at the time."

Under a contract for improvement in the Ohio River, the contractor was stopped when about half way through. He protested to the inspector, saying that he would hold the government responsible. The court said that the contractor's prompt protest and notice of intention to claim damages protected his rights. Damages were awarded to him.

One of the most celebrated cases on this subject was that arising out of the construction of a dry dock in the New York Navy Yard. During the excavation of the pit a quicksand was found, unknown to either the government or the contractor. This greatly increased the cost and the contractor sued for this increase. The Court of Claims, in denying this claim, largely relied upon the fact "that plaintiffs completed the dry dock without complaint and rested quiescent upon their rights or wrongs until they began this action."

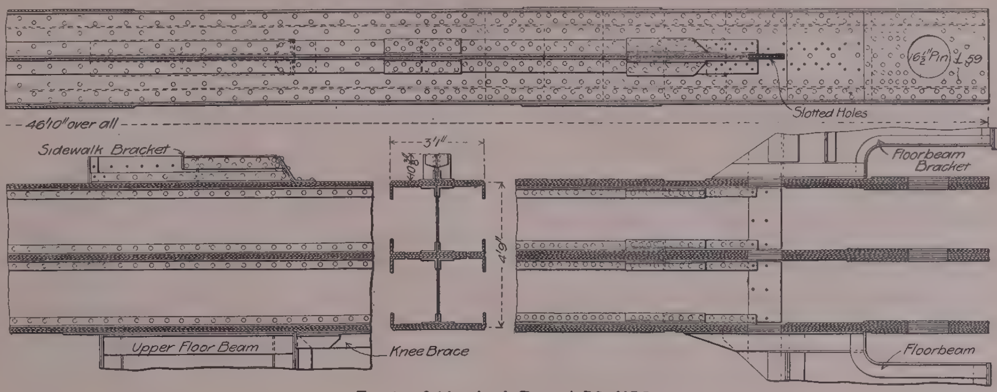
The Supreme Court, even more strongly than the Court of Claims, declared this a valid ground of defense, saying: "Light is thrown upon the plain meaning of the contract by the conduct of the parties in the execution of the work. It is not pretended that, when the character of the sub-soil was discovered, the slightest claim was preferred that this fact gave rise to an extra allowance. The fact is that the contractors proceeded with the work, obtained delay for its completion, made their final settlements and received their last payment without ever asserting that any of the rights which they now claim were vested in them. Without deciding that such conduct would be decisive if the claim was supported by the contract, it is nevertheless clear that it affords a just means of adding forceful significance to the unambiguous letter of the contract and the self-evident intention of the parties in entering into it."

Under the contract for constructing the army buildings at Fort Ethan Allen, a claim was made for a difference in price between the brick named in the contract and that required by the quartermaster. The claim was disallowed because "it is not shown that the claimant protested against the change of the character of the brick used."

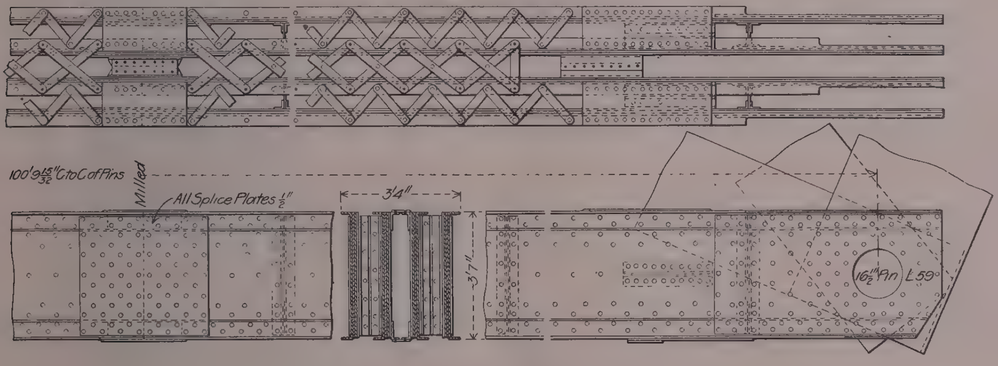
A quartermaster in Cuba refused to take oats as agreed under a contract for the army of occupation in Cuba and cancelled the contract when it had two months to run. The contractor sued for the prospective profits on the omitted deliveries. The contract gave power to the depot quartermaster in New York to reduce the quantities indefinitely. The court admitted that the quartermaster in Cuba violated the contract, but denied the contractor's claim because it was his duty either to tender the oats to the New York quartermaster or to give him such notice of claim as would enable him to exercise his right of reduction.

All these cases show the danger which contractors run of losing their rights altogether by not declaring their objections promptly.

In his valuable work on "Engineering and Architectural Jurisprudence," the author, Mr. John C. Wait, makes a statement which any contractor might properly post in his office as a guide to his proper action in the preservation of his legal rights. He says: "Contractors are frequently characterized as 'troublesome customers,' 'kickers,' 'cranks,' 'sharks' and 'scamps,' and sundry other epithets because they are always objecting, protesting and complaining at what is required of them. But it is submitted that the law encourages and requires the same policy; for a contractor's right to recover often depends upon his having given notice to the company that he considers his rights invaded or the contract requirements overstepped. A contractor should look out for his own interests without regard to the epithets hurled at him or the comments bestowed, and when he feels his rights invaded he should not hesitate to give proper notice of the fact."



Foot of Vertical Post L59 U59.



Lower Part of Main Diagonal L59 U57.

This rule is here primarily stated in relation to private contracts, but it is even more applicable to government contracts, with the addition that the notice ought in all cases to be in writing and must be made to the right person.

When Protest Not Needed.—In some cases the courts have declared that a protest is not necessary. The general principle of such exceptions is that when the invasion of the contractor's right is clear, no government officer could suppose that the contractor acquiesced in it and consequently no protest or notice is needed.

The most conspicuous instance of this was in a well known case for improvement at the Mussel Shoals of the Tennessee River. Here the contract work was multiplied sixfold by extra work ordered and the court said that a protest was not necessary to show that the contractor expected extra pay for this. The general rule was then stated:

"In cases where a public agent has requested a departure from an express contract, it has uniformly been held that if the change ordered was of such a nature that the agent might reasonably suppose no additional expense would be caused, the contractor was bound to speak or otherwise he would be deemed to have consented to make the substitution at the contract price or rate. But, conversely, where the change ordered was of such a nature that it would necessarily involve additional cost to the contractor, it has been held that no notice was necessary and that the contractor could recover his reasonable compensation."

In a similar case at the Norfolk Navy Yard, where a contract was made to restore a building partly destroyed by fire, certain walls were left standing when the contract was made. Afterwards the government officers tore down a portion of the then standing walls and refused to allow additional pay on this account. The Court of Claims treated this matter as so plainly additional work, causing extra cost to the contractor, that no protest was necessary in order to charge the government officer with knowledge of his purpose to claim extra pay.

Protest to Whom.—In some instances it is sufficient to make protest to the officer in immediate charge of the work. In some instances the protest must also be made to the highest officer by whom the original contract was approved. In a general way it may be said that where the claim involves any alteration or extra work, then a protest to the officer immediately in charge is not sufficient, but the higher officer must be notified. In some other cases such additional notice may not be necessary but it is almost never wise to omit it. The only safe rule for the guidance of contractors is that their protests be made both to the officer in immediate charge and to his superior who approved the original contract. It is never safe to rely upon a verbal protest.

Practicability of Protest.—The contractor frequently hesitates to protest against the orders of the engineer, inspector or other local officer because he fears that this will provoke resentment which will in the end result badly to the contractor. Under the usual forms of government contracts such wide discretionary power is granted to the local officer, to be exercised by him without revision, that a widespread fear exists of anything which may produce a hostile feeling on his part. Without plainly stepping outside the bounds of the powers set by the contract and enforced by the courts, the local officer may cause serious loss to the contractor. Consequently, contractors, in fear of worse evils, often submit to lesser invasions of their rights. The question of the contractor's proper course under these circumstances is not one of law but of sound business judgment. Some suggestions may here be made:

(1) All government officers should not be thought so unreasonable as to display personal resentment against the contractor for a fair statement of what he believes to be his legal rights or to use their power spitefully under such circumstances. Many of them would recognize the justice of the contractor's taking reasonable means for his own protection.

(2) Whether such action may be so resented will depend in a large part upon the contractor's mode of making his protests. If careful to observe the amenities of official relations, such a protest may usually be made without provoking harmful animosity. Its meaning will be none the less clear if framed in courteous language.

(3) If the contractor submits to early invasions of his rights, continuance of such invasions is encouraged. A prompt protest is a notice to the engineer that in all his dealings the contractor's rights are to be treated as worthy of consideration. An engineer whose tendency is to override the contractor's rights may be dissuaded from the frequent exercise of such a purpose by knowing that the wrongs will be steadily resisted.

When the protest is once made, what is the contractor's next step in the protection of his rights?

The Contractor May Proceed.—As a general rule it is not necessary for the contractor to abandon his contract in order to protect his rights. When he has made proper protest to show the government that he considers his rights invaded, he is then at liberty to proceed under the contract. This rule was stated some years ago by the Court of Claims in the following language: "If the contractor promptly protests against the government's decision as unwarranted and illegal and notifies them of his intention to claim damages, thus putting the defendants on their guard, it would seem harsh to debar him of his rights because he continues the work with the government's assent under this interpretation."

It is not necessary to refer to instances of this sort because in most of the cases of wrong to the contractor discussed in our previous chapters he went on with his work. He must be careful that proper notice is given at or before the time of final payment that his receipt is not intended to cover his claim for damages or extras which the government does not admit. The details of such notice are fully discussed in the chapter of this work on Receipt in Full. If such protests and notices are given, he may rely upon his claims being considered by the Court of Claims upon their merits and judgment rendered for those which are sound in law and proved by proper evidence. Knowing that there will be a legal controversy over the items in dispute, care must be taken to keep separate accounts of all work and material involved in these. In proving a claim, careful book entries are of the utmost importance.

The Contractor May Stop Work.—When a contractor is ordered to do more expensive work than his contract requires, financial reasons may make it imperative that he shall stop work under the contract. The requirement of the government in violation of the contract may be so onerous that continuance would involve too heavy a financial burden. He may have to choose between abandoning his contract or ultimate business failure. Under such circumstances he has the right to quit work. The Supreme Court over thirty years ago stated this principle, saying of a contractor who was obliged to use better stone in a public building than his contract required, that "when the directions were given he might have refused to comply and given notice to the United States."

The Court of Claims has declared the same principle. In a case for dredging in the Schuylkill River, the monthly payments stipulated to be made by the United States were not paid and the contractor quit work. The Court said: "It seems to us that the law of this case fully authorized claimant to do what he did upon the failure of the defendants to pay according to the requirement of the contract." The Court of Claims relied on a decision of the Supreme Court under a private contract, quoting this language: "In a contract to make and complete a structure with agreements for monthly payments, a failure to make a payment at the time specified is a breach, which justifies the abandonment of the work and entitles the contractor to recover reasonable compensation for the work actually performed."

In a case already cited under a contract for repairing a bridge, where the work was suspended during the Spanish War, it was held that the contractor had a right to quit work.

Thus the principle is well settled that a contractor whose rights are seriously invaded during the execution of his contract may abandon the contract and recover damages.

What Justifies Abandonment.—It is not possible to lay down any general rule to guide contractors in deciding what is a sufficient breach of a contract to warrant abandoning the work. The cases cited have shown some instances where the abandonment was justified. Some cases have arisen under government contracts where the contractor refused to proceed and was held not to have been justified.

During the Civil War the government adopted regulations for the examination of horses offered under contract. The regulations said that they would be applied to existing contracts. A contractor declined to submit his horses to the new regulations and threw up his contract. He then sued the United States for damages, alleging that the regulations were unreasonable and that their application to his contract was a breach by the United States of its terms. The Supreme Court declared that the mere existence of the regulations was not sufficient, since they might not have been enforced against him, and that he could recover no damages, since he had abandoned the contract before they had been so applied. In another case the government refused to receive any horses except under the new regulations, and the contractor, being unwilling to submit to them, abandoned his contract. The Supreme Court held that the regulations were reasonable and did not involve a modification of the contract.

In the former case the Supreme Court stated the following principle: "A mere assertion that the party will be unable, or will refuse to perform his contract, is not sufficient; it must be a distinct and unequivocal absolute refusal to perform the promise, and must be treated and acted upon as such by the party to whom the promise was made."

From these cases the conclusion may be drawn that a contractor may abandon the work:

(1) If payments are not made as provided in the contract.

(2) If his work is indefinitely suspended.

(3) If serious financial burdens not contemplated by the contract are placed upon him.

It is not possible to define exactly what would constitute a sufficiently serious invasion of his rights to warrant quitting work, but this must be determined for itself in each case as it arises.

The Risk of Stopping.—Another practical question must be considered before a decision is reached whether a contractor should continue his work or stop. If he continues, the government has no cause of action against him in any event. He can lose no more than what goes into the work. If he quits, he takes the entire risk of having a sufficient reason. If he is wrong, he will not only lose his own suit but the United States may recover damages against him. Even if he is right, he will probably have to submit to a suit against him by the United States, an adversary with a long pocket-book and an unlimited force of attorneys. The contractor should be confident that he is right before incurring this risk.

He must consider also the effect which it may have upon his credit. The institution of a suit for damages against him by the government in a local United States court may injure his financial standing. Such injury may probably be avoided by his promptly entering suit in the Court of Claims. The claim of the government will probably then be adjudicated as a counterclaim in the same suit and thus will place the contractor in a better public light than if a suit were originally entered against him. The proper course in every such case must be determined on its own merits, upon careful consideration, after a full discussion with a competent professional adviser.

Contracts for Supplies.—Much of the foregoing discussion can apply only to contracts for construction work and can have no relation to contracts for the delivery of supplies. If the United States declines to receive goods contracted for, what is the contractor's duty? Several decisions have been made upon this subject. The cases last discussed show that he must make an actual tender of some portion of the goods remaining to be delivered under the contract, unless the notice of refusal is absolute.

A case came before the Court of Claims under a contract for delivering oats and corn to the army in Texas. An order was issued refusing to receive the portion not delivered, but the contractor after this tendered a portion of the grain. This was refused and notice given him that the refusal would continue. The Court of Claims declared that it was not necessary to tender the entire amount, saying: "In the face of such repeated refusals the claimant was released from the obligation of actually tendering the grain. It would have been an utterly vain and nugatory ceremony for him to have done so under the circumstances." He was allowed his profits on the entire quantity of oats deliverable under the contract.

The Court of Claims has also held that after thus making a tender in part and being refused, the contractor would not be justified in buying enough to complete the tender of the entire amount authorized under the original contract, thus increasing the government's loss in the hope of recovering by suit.

Contract was made for the delivery of oats in Montana and the contractor purchased a large quantity which the government declined to accept. The contractor held the oats for three months on a falling market and then sold them. The court decided that he could not thus delay the sale and charge the government with his losses.

In a very recent case army officers refused to receive oats when presented. The contractor was put to an unwarranted expense in cleaning them by order of an unauthorized board. He sued for this expense but the court said that he could not recover this. Upon the improper rejection of his oats, he should have sold them promptly and sued the government for the deficiency in price.

These authorities show that the contractor's proper course, when the government refuses to take material or supplies deliverable under a contract, is to tender some part of them and upon refusal to sell without delay all which he then has on hand.

Practical Rules.—The result of this examination of authorities enables some practical rules to be formulated which will be of service to contractors in protecting their rights.

1. When the act of any government officer is believed to be in violation of the contractor's rights, he should notify the officer in charge of the work that he so considers it and will claim extra compensation. To insure the sufficiency of this notice he should send a duplicate to the highest officer who approved the original contract.

2. If the act complained of is not of a very serious character or of large financial importance, the contractor should then proceed with the contract.

3. If the supposed unlawful order involves very serious financial consequences, then the contractor may refuse to proceed with the contract, but at his own risk.

4. If he abandons it, prompt notice should be given to the local officer and his superior as above stated.

5. If he goes on with the contract, separate accounts should be carefully kept of all the additional expenses incurred by reason of the acts complained of.

6. If the contract is for the delivery of supplies or material and the government announces that these will not be received, an actual tender should be made of some portion of the goods, and any remaining in the contractor's possession should be immediately sold.

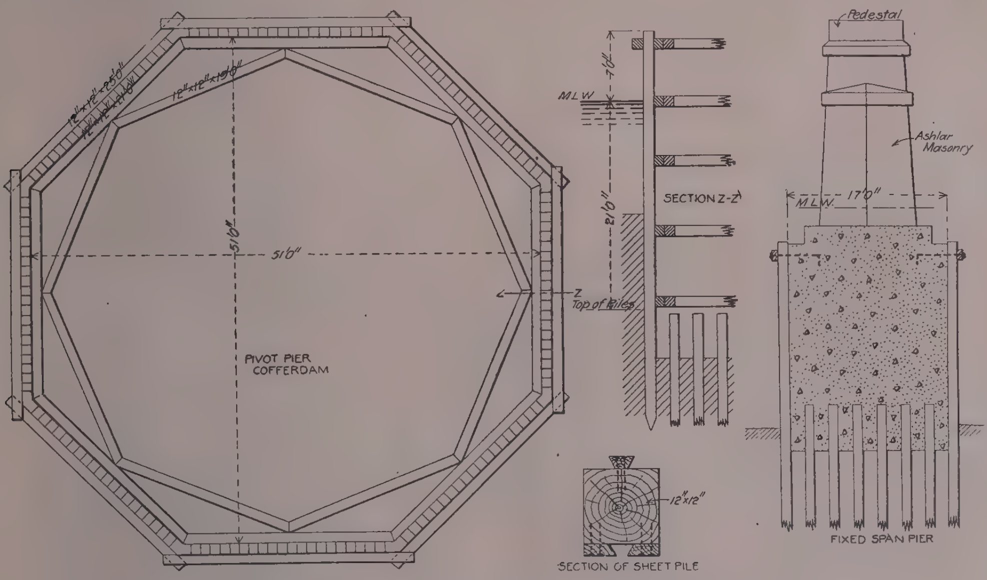
7. When final payment is made, the precautions in relation to the final receipt, more fully stated in the chapter on Receipt in Full, should be carefully taken.

It is not intended by these suggestions to convey the idea that without all these precautions a contractor cannot successfully assert a claim in court. This may often be done. These are the steps which a wise contractor will take so that his rights may surely be preserved for assertion before the proper judicial tribunal.

Substructure of Potomac River Highway Bridge, Washington, D. C.

The new highway bridge across the Potomac River at Washington extends from Potomac Park, Washington, to the Virginia shore, near Alexanders Island, where the river at ordinary high tide has a width of 2,826 ft., a low-water depth of from about 2 ft. to 24 ft., a mean tide of 3 ft., a maximum flood rise of 13 ft. and a current of about 3 miles an hour. It is located about 1,250 ft. up stream from the famous old wooden Long Bridge, which it replaces, and from the adjacent new double-track steel bridge built by the Pennsylvania R. R. Co. in 1904, and illustrated in The Engineering Record of July 30, 1904. The length between centers of abutment seats is 2,667.16 ft. and the maximum clearance of the superstructure above mean high tide is 21½ ft. It has eleven 216-ft. fixed spans and one 290-ft. swing span with two clear openings of 100 ft.

The superstructure is about 61 ft. in extreme width and has two 8-ft. cantilever sidewalks and a 40-ft. roadway with two street car tracks and one line of steel track for heavy wagons bound towards Washington. It is proportioned for 28-ton electric cars, for a 30,000-lb. steam road roller and for a uniformly distributed load of 100 lb. per sq. ft. Both approaches are curved embankments about ½ mile long. The bridge was authorized by acts of Congress of February 12, 1901, and July 1, 1902. The cost was originally limited to $996,000, but $200,000 more was appropriated in 1904 for the approaches. The contracts for the substructure and for the superstructure were awarded to McMullen & McDermott, of New York, and to the Pennsylvania Steel Co., Steelton, Pa., for $500,000 each, and operations were commenced by the former company in the fall of 1903.



Typical Fixed Span Pier and Cofferdam for Draw Span Pier.

The eleven piers for the fixed spans are 8 ft. wide and 50 ft. long below the coping, with a side batter of 1 : 16 and up and down stream cutwaters. Down to 2 ft. below mean low water level they are built of rock-faced granite ashlar backed with concrete laid in 8-in. courses and thoroughly rammed with heavy iron rammers. The cut granite coping is 18 in. thick and the stones are cramped together by ⅝-in. iron bars let into them 3 in. Below the granite the piers are of concrete enclosed in permanent wooden sheathing and supported on piles which extend 5 ft. into it and are cut off in horizontal planes from 10 to 21 ft. below mean low water. The abutments and pivot pier are of similar construction, but have different dimensions and shape.

The alignment and location of the piers was given from stations on clusters of three piles each about 50 ft. up stream from the center of each pier and on its axis. These stations were located by triangulation from shore and were frequently checked. A transit was set up on the center point marked on the pile platform and was lined in with a line parallel with the axis of the bridge; it was then turned 90 degrees and the distance to the pier center laid off approximately by a steel tape, which determined the location of the caisson sufficiently close. The center line of the bridge was spotted in direct from permanent points established on both shores.

At the site of each pier the bottom of the river was excavated to a depth of from 19 to 30 ft. below low-water mark, and from 3 ft. to 15 ft. below the original bottom by the 1½-yd. Hayward bucket of a floating dredge, which delivered to dump scows moored alongside. Where the bottom was gravel the excavation was made only as far as the base of the concrete footing, but where it was mud, the excavation was carried 4 ft. below the bottom of the concrete footing and the latter was subsequently started on a backfilling of sand delivered by scows and carefully leveled by divers.

At each pier a sheet pile cofferdam was driven with inside dimensions exactly corresponding to the outside dimensions of the concrete foundation. The cofferdams were made with one square end and one V-shape end, and at each angle of the five walls a compound corner piece, made with two pieces cut from 112x12-in. timber and belted together with a mitre joint, was first driven to provide initial points for commencing and terminating the intermediate pile driving.

Three transverse two-pile bents were driven inside the cofferdam, one near the center and the others near the ends of the pier to support the frame that guided the sheeting, and their 12x12-in. caps projected at each end about 3 ft. beyond the inner faces of the cofferdam and carried inside and outside walling timbers between which the 12x12-in. and 9x12-in. sheet piles for the sides of the cofferdam were driven. A second set of walling pieces was leaded and suspended 8 ft. below the first set and about 4 ft. below low water and served to maintain the transverse alignment of the sheeting as it was driven.

The sheet piles were made with bevelled splines forming dovetail tongue and groove joints and were driven to a penetration of about 5 ft., their tops being 6 ft. above low-water level. They were driven with a 2,500-lb. hammer, and in order to allow the piles to clear the leads of the regular driver frame the hammer was set in special short leads about 10 ft. long, which telescoped in the regular leads, projecting outwards with a 3-ft. offset, and being suspended from the top of the tower by a tackle operated by the hoisting engine. The sheet piles were driven by an ordinary floating machine and there were five closures for each cofferdam which were made without difficulty, the last pile being made of special width to correspond with the space left between the adjacent piles. Mud was dredged from the river bottom and backfilled around the outside of the cofferdam to fill the excavation made for the pier and bring the river bottom to its original elevation.

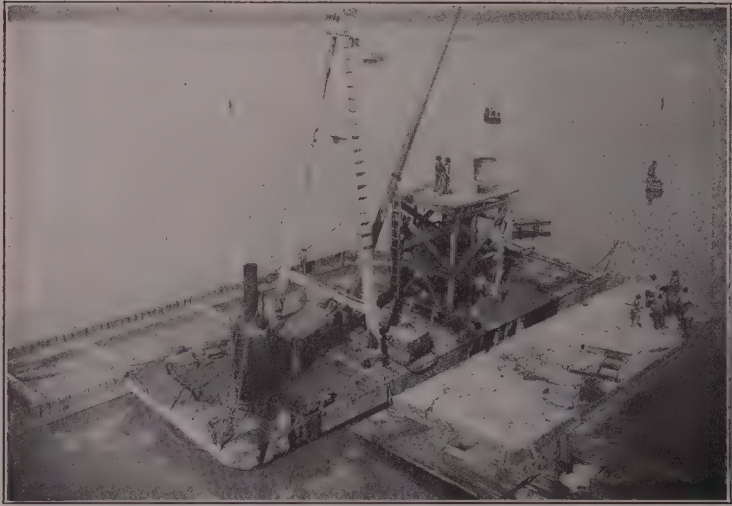
In each of the fixed pier cofferdams about 160 12-in. yellow pine piles about 60 ft. in maximum length, were driven by a 3,500-lb. hammer in an ordinary land pile driving machine supported on timbers across the top of the cofferdam. The hoisting engine moved with the pile drivers and the pump and its boiler were stationarily located on a temporary platform supported by a row of piles driven parallel with the down stream end of the cofferdam.

The pile leads were determined by the formula $L = 12\,WH \div (S + 1)$, where L is ultimate bearing power in pounds, W is weight of hammer in pounds, H is fall of hammer in feet and S is penetration in inches, under last blow. The safe load was assumed to be one-sixth of the ultimate load and the coefficient was modified in accordance with the results of a number of tests on piles driven at the site in September, 1901. Eight piles from 40 to 70 ft. long were driven through water from 2 to 20 ft. deep to penetrations of from 11 to 71 ft. in the bottom. Records were made of the penetrations under one blow of a 2,000-lb. hammer falling 10 ft. For the longest pile the penetration at a depth of 37.7 ft. below the bottom of the river was 0.43 ft. and at the final depth of 71.1 ft. it was 0.08 ft. For the shortest pile it was 0.04 at 9.5 ft. and 0.03 at the final depth of 11.4 ft. For the other piles the penetration varied from 0.4 ft. to 0.016, the minimum being for a pile driven 11.4 ft. into the bottom, where the water was 17.5 ft. deep.

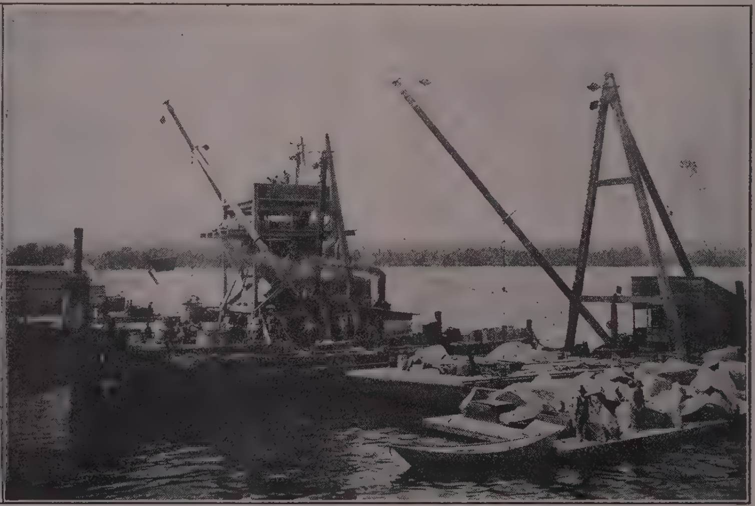
As soon as the foundation piles for each pier were driven the cofferdam was sealed by depositing in it 3 ft. of concrete made 1 part Old Dominion Portland cement, 2 parts sand, 2 parts fine broken stone and 3 parts coarse broken stone. This was deposited under water between the piles by a special cylindrical steel bucket 18 in. in diameter and 7 ft. long with a trip bottom. The concrete was allowed to set four days and the cofferdam was pumped out with a 6-in. or an 8-in. centrifugal pump. As the cofferdam was pumped out divers stopped the leaks from the outside which developed in some cases from injuries to the splines in the sheeting, etc., and the lower tiers of 12x12-in. braces from 4 to 6 ft. apart, vertically was set to resist the increasing external pressure. No difficulty was experienced in emptying the cofferdam except in one instance, where there was a gravel bottom. The piles were cut off by hand with cross-cut saws and the cofferdams were filled up to elevation 2.0 with concrete deposited by a 1-yd. bottom-dump steel bucket and thoroughly spaded around the sides of the cofferdam. Clean good stones of 9 cu. ft. volume or more were set on mortar beds in the concrete and the concrete was carefully tamped. About 600 cu. yd. of concrete were required for each fixed span pier and it was laid in an average of three days, the interior braces being removed from the bottom up as it was laid. Near the top of the concrete horizontal transverse ⅞-in. steel hook rods 5 ft. long were put across the cofferdam with nuts bearing on the 6x12-in. outside walling pieces; these were built in solid in the concrete and remain there permanently, securing the sheeting to the pier.

The pivot pier is 47 ft. in diameter above water level and is built with concrete and granite masonry on a pile foundation, as described for the fixed span piers; the cofferdam is, however, octagonal and thus differs from the long and narrow ones used for the other piers. It was made with 12x12-in. sheet piles driven between two sets of inner and outer walling pieces and braced by five tiers of horizontal braces. Each tier was made with eight 12x12-in. horizontal pieces with mitred butt joints forming an octagon, each side of which was braced in the middle by the vertex of a concentric octagon. also made with 12x12-in. timbers with mitred butt joints, thus forming a complete ring which acted as an arch, resisting the external balanced pressures. A special compound pile made with two mitred timbers bolted together to form a corner piece was first driven at each angle of the cofferdam and the sheeting was started at each corner and completed with eight closures, for which special pieces were made to measurement when necessary. This construction was simple and efficient, provided the maximum working space unobstructed by cross braces, and satisfactorily resisted the 30-ft. head to which it was subjected.

Concrete was mixed in a Hains mixer set in a tower about 35 ft. high built on a scow and moored alongside each pier successively as the work progressed. Between the mixer scow and the pier was moored a derrick scow and on the opposite side of the mixer scow were moored successively another derrick scow, a stone scow and a sand scow. The cement storage scow was moored close to the downstream end of the mixer scow and the whole fleet was secured by lines to a cluster of piles upstream from the piers. On the opposite side of the pier was moored first a derrick scow and then a rubble stone scow. In this way all materials were within reach of the pier and were conveniently handled by the three derricks with beams 45 to 65 ft. long. There was a small stone and sand storage bin over the mixer tower, and bags of cement were lifted on scale pans to the charging platform. All the derricks were operated by 7x10-in. Lidgerwood, Rawlins, Lambert and Mundy hoisting engines and the rapidity of the work was limited only by the ability to remove concrete from the mixer. Concrete was delivered by the mixing machine to a 1-yd. steel bucket on a short narrow-gauge railroad track on the deck of the scow. The car was pushed by hand from under the concrete tower and the bucket lifted from it and emptied where required in the cofferdam or pier masonry by the derrick.



Concrete Scow and Cofferdam from above.



Fleet of Scows from Pivot Pier.

The total quantities involved included about 18,000 yd. of dredged excavation, 1,500 yd. of permanent sand backfilling, 2,500 piles, 850,000 ft. b.m. of timber and 12,000 cubic yd. of concrete, including cyclopean stones bedded in it and 6,000 yd. of stone masonry and backing. An average force of about 125 men were employed on the work and the work was prosecuted uninterruptedly, without delay from storm or other serious trouble. The maximum high water was not reached during the progress of the work, the highest flood being only 8 ft. above low water.

The bridge was built for the United States War Department under the successive direction of Lieut.-Col. C. J. Allen, the late Col. A. M. Miller, Lieut.-Col. S. S. Leach and Lieut.-Col. R. L. Hoxie, all of the Engineer Corps, U. S. A. John Meigs, Jr., was resident engineer for the Government and Mr. Howard J. Cole and Mr. W. L. Christie were, respectively, engineer and superintendent for the sub-structure contractors.

Novel Sewage Treatment.

Sewage treatment of a novel nature has been practiced at Oberlin, O., which is described in the eighteenth report of the Board of Public Affairs as follows: For a number of years the amount of sewage has been increasing so rapidly that it was considered best to add some coagulant in order to increase the precipitation of the solids at the sewage farm. The latter was 3½ acres of land which has been underdrained, and 1¾ acres not underdrained, which is used for broad irrigation. The average amount of sewage received daily at the farm is about 250,000 gal. Sulphate of alumina was used as a coagulant for a number of years, but in 1903 sulphate of iron was adopted. This is introduced into the sewage at a point in the outfall sewer near the place where the last branch sewer is taken off. Lime is also added.

The New Water Works which are being discussed at Los Angeles will cost $36,800,000, according to estimates by Mr. Frank H. Olmsted. This is an enormous sum for a city of 105,000 population to pay for such works, and its amount is due to the $26,500,000 which the conduit, over 250 miles long, will cost. In order to construct the conduit it will be advisable, Mr. Olmsted says, to build a railway costing over $5,000,000 along the line and to erect three 600-barrel cement mills. Considerable revenue is estimated as possible from three hydraulic power developments that can be made.

The Office of Public Roads.

Excerpt from the report for 1905 of Hon. James Wilson, Secretary of Agriculture.

Probably no field of work is of greater interest to the public at large than the improvement of our highways. The Office of Public Roads, as now constituted, represents a distinct stage in the development of the work undertaken by the Federal Government in 1893 by the establishment of the Office of Road Inquiry. At the time of the establishment of the Office, the lack of a knowledge of existing conditions was a serious hindrance to an intelligent application of any plan for road improvement. The name originally chosen for the Office was suggestive of the purpose of Congress, which was to inquire into systems of road management throughout the United States, and into methods of road making, and to disseminate information as to the results of such inquiries.

The most important result which has been attained up to this time, whether produced by influence in or outside of the Office of Public Road Inquiries, is that the people in all parts of the country are now interested in the subject of road improvement, and are seeking such information as will enable them to carry on the work along intelligent lines. It was found, therefore, that the collection of information must of necessity become only one feature of the work of the Office, and that facilities must be provided for answering as well as awakening inquiries. At the same time the necessity for demonstrating scientific and economical methods of road construction instead of mere agitation has been clearly established.

Expert Advice and Object Lesson Road Work.—The work of the Office is primarily educational in character. Its province is to detail engineers and experts to give information and advice. Whenever there is any question as to what road material is best suited for the local conditions, samples of all the available materials may be sent to the laboratory of the Office, where tests will be made to determine the selection of the best material. In the majority of cases the detail of an engineer or expert to make a preliminary investigation and give advice is all that is required. There are, however, communities where it has been found advisable to supplement advice by practical demonstration of effective road building.

To meet this need the object-lesson method was adopted on the following plan: A section of road is selected for improvement, and after the proper surveys and estimates have been made by an engineer of the Office, expert foremen and machinery operators are sent out in charge of modern road-building machinery, and the local officials are taught by actual demonstration every step in the proper construction of a road. Absolutely no expense is incurred by the Federal Government in this work except for the salaries and expenses of the Government employes, the local communities being required to furnish the right of way, all common labor, teams, materials, etc., used in the work. The total number of experimental and object-lesson roads built under the direction of the Office since its organization is 96, with a total length of about 39 miles. The roads were built in 28 States, the materials used in construction being shells, gravel, brick, oil, tar, sand-clay, marl, stone, burned clay, slag, and steel track.

Four complete road-building outfits were placed in the field at the beginning of the past fiscal year, and their work has continued without interruption. Twenty-one sections of road have been built during the year in nine States, the total length being a little over 9 miles. In the construction of these roads a variety of materials was used, such as stone, shale, burnt clay, sand-clay, shells, gravel and marl. The detailed reports submitted by the engineers in charge of work show a maximum cost of 98 cents and an average cost of 55 cents per square yard for macadam roads, while the average cost of sand-clay roads is shown to be 9½ cents. The only burnt clay road constructed was built at a cost of 20 cents per square yard. In the work done under Government direction there was of necessity a great variation in cost on account of the difference in cost of labor and teaming, amount of grading required, length of haul, and general efficiency of labor.

Fixed Span Pier in Cofferdam, Potomac River Bridge.

Pile Footing and Interior of Cofferdam for Pivot Pier.

Since the passage of the act of Congress approved March 3, 1905, creating the Office of Public Roads, steps have been taken to place the field work on a more systematic and businesslike basis than heretofore. This has been to some extent accomplished by increasing the force of engineers and experts and decreasing the number of men detailed as public speakers and lecturers.

A circular of instruction defining object-lesson road work and expert advice within the meaning of the act of Congress, and setting forth the terms under which this Office is prepared to grant assistance is sent out in answer to inquiries on the subject. A blank form of application for expert advice and assistance has been prepared, which is required in every instance to be filled out and signed by the local authorities.

The construction work is at present under the management of trained engineers, who are assisted by experts qualified to operate all road-building machinery. When an object-lesson or experimental road is to be built, complete surveys, plans, specifications and estimates are prepared and the fullest preliminary information is obtained. As far as practicable itineraries are made up for each party in the field, covering a considerable period of time, in order that the greatest amount of work may be accomplished with the least expenditure of time and money. The work is planned so that it may be carried on in the North in summer and in the South in winter, thus avoiding interruption as much as possible.

There appears to be a growing need for the construction and maintenance of roads in the forest reserves. In view of the fact that the Office is maintaining a gradually increasing corps of competent highway engineers and experts, it would seem to be a wise arrangement to utilize the services of these men, wherever practicable, in the construction and maintenance of roads in the forest reserves and other areas which are now or which may hereafter come under Government control.

Heretofore machinery has been borrowed from the manufacturers who have been willing to lend it for the construction of the object-lesson roads. Transportation for men and machinery has usually been secured free of charge from the railroad companies, who have generally shown themselves ready to co-operate on the ground that improved highways directly benefit them. The practice of borrowing machinery and of depending upon free transportation is not, however, the best policy. Gratuitous assistance inevitably tends to hamper that freedom of action on the part of the beneficiary which is essential to the proper performance of the work intrusted to public officials. A plan for leasing machinery at a certain per cent. per annum of the list price is being favorably considered, and, if the request for an additional appropriation to make this arrangement possible is granted, it is probable that ten outfits of machinery will be secured and placed in the field. It has been ascertained that this plan is perfectly feasible, and that the machinery can be secured at a fair and reasonable rental. Should the recommendation in regard to an appropriation to cover freight charges meet with approval the old practice of free transportation will be abolished.

Experimental Field Work.—There are vast areas in the country in which stone is not available for road making, and in only a few localities has it been found practicable to overcome the difficulty, on account of the cost of transportation. In such cases the problem is how to obtain a suitable substitute. In some sections of the South roads have been built of mixtures of sand and clay. These roads have generally proved satisfactory, and the efforts of the Office have been directed toward originating special methods for putting such materials to use.

In the great Mississippi Delta the use of burned clay or gumbo has been introduced, under the direction of the Office, with what would seem to be marked success. This is shown by the results obtained on an experimental burned-clay road constructed at Clarksdale, Miss. Previous to the construction of this road experiments had been made in the laboratory of the Office to determine the best method of burning the clay. This experiment may possibly prove of value to other parts of the country, for instance, in many of the prairie States, in which no other form of road-building material is available. The report from the South on this special form of construction has been most encouraging, one county alone having appropriated $25,000 to be expended principally in this way in the immediate future. Roads of this nature are said to be more economical, efficient and lasting than gravel roads which have been constructed in the same section.

In addition to the study of the various methods of construction and their application to those large sections of the country which at present enjoy few if any improved roads, considerable attention has been given to problems in the maintenance of roads. These have particularly to do with the suppression of dust, which has already received the attention of the French Government road engineers, as well as those in England and elsewhere, for the past seven or eight years. It is now occupying the attention of highway engineers in this country. A treatment which will retain the dust on the surface of a macadam or gravel road is of special value at present, owing to the great damage done to such roads by motor-car traffic, which has the effect of loosening the dust to such an extent as to seriously damage the road.

Extensive experiments for laying dust by the application of oil and coal tar on macadam and earth road surfaces have been conducted by the Office during the past year at Jackson, Tenn., and it is hoped that the data and information to be obtained from these experiments will be of great interest and value. In this connection it might be mentioned that perhaps more inquiries are received concerning the use of oil and tar than on any other phase of the work of this Office. At present there exist few or no exact data on this subject, but it is believed that the experiments referred to will in a great measure answer many of the questions that are now in doubt.

There are at present a number of patented solutions which are recommended to lay the dust on roads more effectively and economically than water sprinkling. It is expected that investigations will be carried on in the laboratory of this Office to ascertain the relative effect of various chemicals which may be used in sprinkling streets and roads.

Instruction in Highway Engineering.—In order to secure engineers having the necessary technical training as a basis, and to supplement such training by special work in highway engineering under the direction of the Office, the plan has been adopted of appointing graduates of reputable engineering colleges to the position of civil engineer student in the Office of Public Roads. These young men are required to pass rigid competitive examinations before entering the service and receive practical and scientific instruction and work for the period of one year, this being in the nature of a graduate course in highway engineering. At the end of that time they are given a certificate in the nature of a diploma, and may be retained in the service without further examination.

The work of these students includes personal inspection and reports in detail of the methods of construction carried on by different State highway commissions in the States where such work has been systematized and put upon a practical basis. They are also required to make surveys and estimates of the actual cost of building roads under various local conditions. Thorough training in methods of testing the various qualities of road materials is acquired by actual work in the laboratory, so that the value of the different physical properties of the materials may be made clear to them. The work of these engineer students is of great assistance to the Office, in addition to being of much practical value to the public at large.

It is of the utmost importance that the great sums of money appropriated for road improvement throughout the country should be expended wisely, under the direction of properly qualified men. At the present time the number of trained highway engineers is entirely inadequate to meet the demand. It will be of inestimable value to the public if the Office can provide even a few such men each year. Instruction in highway engineering in schools and colleges throughout the country should receive greater attention at the present time, owing to the rapid development of road building. The Office, so far as its limited facilities permit, will cooperate with the various educational institutions in placing this branch of education on an adequate basis and in inaugurating highway work.

Testing of Materials and Special Investigations.—One very important feature of the development of the work of the Office has been the testing of materials available for roads in different parts of the country and the investigation of special qualities which are necessary if the most successful results are to be obtained. A large number of tests have been made on all the different kinds of materials which are in use in the construction of highways, and in addition to these routine tests a number of important and valuable investigations have been carried on. By far the greater number of tests have been made for the benefit of State and municipal authorities who have evinced a desire to obtain accurate data to enable them to make a careful and wise selection of the best material at hand. The best indication of the importance of this work is shown by the fact that many of the State governments are establishing laboratories and conducting work along the same general lines that have been followed in the laboratory here.

The equipment of machinery necessary for testing road materials is also available for testing other materials of construction relating to agriculture, and thus duplication of equipment is avoided by extending the scope of the work of the Division of Tests. It has been possible to undertake several investigations which bear directly upon problems that the farmers of the country have to face.

For some time past numerous complaints from a variety of sources have reached the Department concerning the inferior lasting quality of the steel-wire fencing offered in the market at the present time. Preliminary inquiry showed that these claims were well founded, and a thorough investigation was ordered. Enough has already been accomplished to show that the farmers will derive great benefit from this work. The interest of manufacturers has been aroused to the extreme importance of this matter, and measures are already being taken in many of the leading manufactories to bring about an improvement in the conditions complained of. When it is considered that much of the wire which was produced thirty years ago is still in good condition, whereas the life of wire put on the market in more recent years is often not longer than two to seven years, the money saving to the farmers of the country that will be brought about by the improvement in present conditions becomes apparent.

The fact that in many parts of the country it is difficult to procure wood for fence posts, added to the fact that wooden posts rapidly decay, has stimulated the desire to present the farmers with simple information and directions that will enable them to make use of reinforced concrete. Reinforced-concrete fence posts of various types have been made in the laboratories and tested.

One of the most important qualities possessed by rocks which render them useful for macadam-road building is that of binding power. A study of this important quality has been one of the principal subjects of investigation by the Division of Tests, and several valuable bulletins have been published setting forth the results obtained. In the course of this work it was observed that when some rocks are ground to very fine powders they undergo certain decompositions, owing to the action of water. In view of the fact that many of our large rock deposits are rich in potash, and in view of the extent to which these decompositions are found to take place, it becomes apparent that if the rocks are subjected to a process of fine grinding it is possible that they may be directly available as fertilizers.

The importance of this subject of investigation cannot be overestimated, when it is considered that no original source of potash exists in this country to-day and that we are entirely dependent upon foreign sources of supply for all the potash used annually by our farmers and growers. The further investigation of the possible source of supply will be vigorously pushed in the various bureaus of the Department which are especially equipped for carrying on work of this nature. Under the stimulus of the cement industry, which has grown to enormous proportions in this country, the development of machinery for grinding rock to fine powders has made rapid strides within the past few years, and it is now possible to consider the feasibility, from an economic standpoint, of grinding material which a few years ago would have been out of the question.

In view of the growing importance of the cement industry to-day it is necessary to prosecute studies and inquiries into the actual constituents and character of Portland cement, and to this end an agent of the Office was assigned to work on this subject.

It is proposed during the next fiscal year to carry out investigations along the same general lines, adding from time to time other problems of a similar nature in so far as time and equipment will permit.

Collection of information.—While it is known in a general way that some parts of the country have progressed much further than others in the matter of road improvement, there is little available information regarding what has been accomplished in the various States and counties. If comprehensive statistics were available it would be shown that large sums of money are annually wasted in some sections, while in others surprisingly satisfactory results are obtained at a moderate cost. The Office is now collecting information from every county in the United States in regard to the mileage of improved and unimproved roads, the amount of cash tax, bonds issued, and other information of a similar nature. No more telling argument for reform in wasteful methods can be adduced than to bring home to every county just what results they are obtaining as compared with the results obtained by other counties at a similar cost. This information, which is now being compiled, will be published for each State as soon as completed.

Conventions.—Government participation in road conventions and the organization of road associations has been considerably curtailed during the past year. Such participation does not seem to be justified when the sole object of the meeting is agitation for the purpose of influencing legislation. Aside from the propriety of the case the results achieved through speeches by Government employes at popular gatherings of this character can scarcely be considered as having a marked influence upon the progress of road improvement in the United States.

There is, however, a field of real usefulness to be reached by means of speakers and lecturers of the Office. Road organizations serve a useful purpose in arousing the people to a realization of the need for better roads. The problem that is most serious to rural communities, and one which it should be the province of specially equipped employes to explain at meetings of local officers and taxpayers, is what they need, how to go about getting it, and what their roads will cost. These speakers should be so well equipped that they can give definite and concise information, on which the local committees may act with safety.

Another branch of this work capable of beneficial results is a co-operative system of lectures in engineering schools throughout the country. As already stated, the demand for skilled highway engineers is already in excess of the supply and the educational institutions of the country should take prompt and adequate steps to meet the situation. Aside from the engineering features, there are many economic questions involved that should be brought out in lectures to students who intend to devote their lives to highway work.

Much of the work embraced in the scope of the Office is of a scientific and technical nature and involves original thought and investigation. Papers should be prepared and read at the meetings of scientific bodies, and properly qualified members of the Office should keep in touch with organizations having under consideration matters bearing in any way upon the purposes for which the Office was established.

The Intake at Evansville, Ind., has been a constant source of annoyance since it was built, and a fortnight ago the contractors who have been endeavoring to repair it notified the Water-Works Trustees that they could not carry on such a losing venture under the old terms. The trouble was caused by the bad character of the foundations in this vicinity which not only resulted in breaks in the conduit, but caused part of the pumping station to collapse, as illustrated in this journal on Aug. 13, 1904.

Indiana Coals.

A paper read before the Indiana Engineering Society by Mr. R. P. King, Indianapolis.

The State of Indiana is looked upon by the country at large as a highly agricultural region of hog and hominy; yet she has been one of the first six of the coal-producing States for nearly a decade. The growth of the industry in this State has been somewhat eratic, due to railroad and other conditions, for instance, in 1903, during the anthracite coal famine, the production of Indiana coal jumped to nearly 12,000,000 tons per year.

The map of Indiana shows that 21 counties, comprising 7,000 square miles or one-fifth of the State, are underlaid with coal, at least seven distinct veins of workable thickness being found. In some places the veins are 25 ft. thick, although they generaly average from 3 to 11 ft. The mines are all on the line with the railroads, or within a mile or two of them. In fact, many of the mines can be seen from the windows of trains passing on the main lines. Several new railroads projected or now building will open up new territory that has not yet been worked.

The coal from the Indiana district is high in volatile matter, sulphur, moisture and ash, making economical combustion exceedingly difficult. To offset these difficulties is the remarkably low price for which this coal can be sold. Here in Indianapolis, a city of nearly a quarter of a million, with unrivaled railroad shipping facilities, steam coal can be bought on the track for a dollar a ton.

A comparison of the cost of steam power in Marion County, Ind., and water power at Derby, Conn., is exceedingly favorable to the former. The Ousatonic Water Co., of Derby, charges one consumer $20.00 per h.-p.-year, the water being delivered at the purchaser's headgates. With interest and attendance, this amounts to $26.72 per h.-p.-year, for a 12-hour day. With water becoming more and more unreliable each year as dry seasons become common and water powers are loaded beyond their limit, no plant is complete without its steam auxiliary, an additional expense not estimated above. In passing it might be mentioned that contracts with water power companies are usually made on long time, secured by second mortgages. With a steam plant in idleness, the power charges are reduced to a minimum, while under the water power system the charge remains practically constant.

At Indianapolis the charge per horse-power-year for large steam plants is about $21.00, and for small steam plants it is $27.20. In addition to this, nearly all plants have a use for exhaust steam for heating or other purposes, which is so much clear gain.

The cost of coal to the consumer is dependent on two things, the cost of production and the freight. The calorific value of the fuel has absolutely nothing to do with the selling price. That coal is then the cheapest, which contains the greatest number of heat units for a given price, provided, of course, that there is no unusual difficulty attending its use.

The heating value of a few representative coals is as follows:

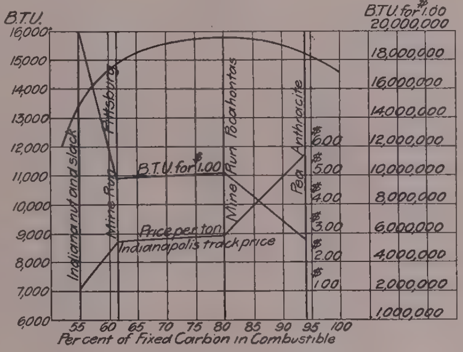
Pocahontas, 15,200 B.t.u.; Cumberland, 14,400; anthracite, 13,420; Pittsburg, 13,410; Ohio Jackson, 13,090; Big Muddy, Ill., 12,420; Brazil Block, 12,300. This gives an idea of the coal from different districts.

The Indianapolis track prices for these grades are.

	Price.	Dist. hauled, miles.
Pea anthracite	$5.75	600
Pocahontas	2.95	400
Pittsburg	2.75	350
Ohio Jackson	2.30	250
Big Muddy	2.00	200
Brazil nut and slack.............	1.10	50
Cumberland (none in the market).		

The difference can be more forcibly illustrated by the accompanying chart, which shows the variation in the calorific value of the four coals platted, Pocahontas occupying the highest place and containing the greatest number of heat units for any possible combination of carbon and hydrogen. The lower line is the heat units that can be purchased for a dollar. Here the Indiana coal shows way in the lead with 20,000,000 heat units for a dollar; Pocahontas with one-half that number and anthracite only one-third as many. The question of which coal to buy is not difficult to answer, as no one in Indiana can afford to burn anything except Indiana coal.

Before going further let us consider rapidly the cost of power in Indianapolis, using various sources of energy. From tests published by various parties and assuming Indianapolis prices, the cost of evaporating 1,000 lb. of water with Pocahontas coal is 13.5 cents; with Pittsburg coal, 13.5 cents; natural gas at 10 cents per M., 11.15 cents; with crude oil at $0.65 per bbl., 14.0 cents; with Indiana coal, 9.0 cents. The cost of evaporation given for Indiana coal is not taken from a performance with the "Standard" of Hartford setting but from tests on a furnace designed by the writer. The fire-box is roofed with fire-brick and a fire-brick combustion chamber is provided behind the bridge wall.



Value of Coal in Indianapolis.

In large plants run continuously or served by mechanical stokers, it is possible to reduce the cost of evaporation to 8 cents per 1,000 lb. or even less than that.

The cost per brake horse-power-hour with a gas engine and suction producer is 2.7 mills as a minimum, and the usual guarantee is 4.5 mills; a gas engine using natural gas will give a h.-p.-hour for 1.22 mills; with illuminating gas at 90 cents per M, 18.0 mills; with fuel gas of 600 B.t.u., 13.4 mills; with gasoline at 12 cents per gallon, 12.0 mills; and with kerosene at 8 cents per gallon, 10.0 mills. The steam per boiler h.-p. (34.5 lb.) as above, 3.1 mills.

In order to makes these comparisons it has been necessary in some cases to supply Indianapolis prices and in other cases to supply efficiencies. Most of these figures were, however, furnished by manufacturers of this class of machinery.

A few sources of power not yet considered are the hydraulic engine, using water at 40 lb. pressure, and furnishing a h.-p.-hour for 216 mills; electricity from a central station, 37.0 mills; and an oil engine averaging 3.03 mills.

In these comparisons the steam engine recognizes no competitors except those systems where the cost per brake horse-power falls below 1 cent per hour. We have then for competitors of the steam engine, the gas engine with suction producer, 2.7 to 4.5 mills; gas engine with natural gas, 1.22 mills; oil engine, 2.76 to 3.03 mills; with steam at 0.31 cent per boiler horse-power, the cost per horse-power with slide-valve engines is 6.0 mills; automatic engines, 3.0 mills; and compound engines, 3.0 mills. High efficiency engines and turbines are lower than that.

One reason for the dearth of information on western coal is that the "Standard" coals recommended by the Am. Soc. M. E. are anthracite, Clearfield, Cumberland, Pocahontas, New River and Pittsburg. To quote from the rules for boiler tests recommended by that society, "These coals are selected because they are about the only coals which possess the essentials of excellence of quality, adaptability to various kinds of furnaces, grates, boilers and methods of firing, and wide distribution and general accessibility in the market." In accordance with these recommendations one would expect to see an efficiency gurantee so worded as to promise a certain evaporation with one of these standard coals, no matter whether the owner expected to burn that coal or a cheap grade of Indiana slack or a still worse lignite. It is but fair to add that Big Muddy lump is suggested as being "of sufficiently high grade to answer the requirements in districts where it is more conveniently obtainable than the other coals mentioned above."

The performance of a boiler with any of these standard coals is of absolutely no value to an owner unless he expects to use that coal. What a man wants to know is, not what results can be obtained with standard coal, but what his future coal bill will be under actual commercial conditions.

The same dearth of reliable data exists with reference to furnace proportions for use with coals mined in this State. These conditions are usually expressed in ratios, the grate area being referred to as unity. Rates of combustion are also very vague and of chimney formulas there is no end. While the writer's experiments are not sufficiently advanced to warrant the laying down in this paper of a set of rules, he will point out some of the weak points in the current practice among hand fired plants in this city.

Our eminent authority, Mr. Barrus, after considering the correct proportion for anthracite and bituminous coal gives the following: "These examples indicate that a much larger amount of heating surface is required for obtaining the full efficiency of bituminous coal. There is sufficient reason for this requirement in the fact that bituminous coal is of a gaseous nature and the heat generated in its combustion is spread through a larger space. The temperature of the escaping gases in the same boiler is invariably higher when bituminous coal is used than when anthracite is used and this points to the same characteristic. It would seem then, that if a ratio of 36 to 1 is sufficient for anthracite coal, from 45 to 50 should be provided when bituminous coal is burned, especially in cases like those referred to when the rate of combustion is above 10 or 12 lb. per square foot of grate per hour."

The data upon which this opinion is based are not from experiments on what can be called bituminous coal under the usual classification. Of the 136 tests tabulated, but four were on bituminous coal and of these four but one was with coal mined west of the Allegany mountains. Mr. Kent wisely abstains from committing himself to any set of furnace sizes, but gives instead what he calls a common rule for horizontal tubular boilers, as follows: Ratio of grate to bridge wall, 1:7; grate to tubes, 1:8; grate to chimney, 1:9. This is not far from Mr. Barrus' practice, which is with anthracite and is as follows: Grate to heating, 1:36; grate to tubes, 1:9 to 1:10. With bituminous (?), grate to heating, 1:40 to 1:50; grate to tubes, 1:6 to 1:7.

Mr. Kent follows his discussion with the remark: "The tube area should be made large enough not to choke the draft and so lessen the capacity of the boiler. If made too large the gases are apt to select the passage of least resistance and escape from them at a high velocity and a high temperature." This leaves us still in doubt as to the proper proportion. It is doubtful if anything so simple as the foregoing formulas can be broadly applied to different localities and coals. For example, the 80-h.-p. boiler at the Park Theater, which conforms approximately to the Barrus bituminous practice, has a heating surface of 990 sq. ft. and a grate surface of 22.5 sq. ft. The ratio of grate to heating surface is 1:44; of grate to tubes, 5:1; of grate to breeching, 7:1. With Pittsburg coal at rating the consumption is 14 lb. per square foot. When burning Indiana coal with this boiler, to increase the draft so that a rate of 25 lb. per sq. ft. per hour is maintained would be well within the limits of good practice. For this plant we would then have a heating surface of 990 sq. ft., a grate area of 16 sq. ft., and a ratio of grate to heating surface of 1:62; grate to tubes, 3.5:1; grate to breeching, 5:1.

Here we have a case where we would be burning more coal, and therefore passing an increased quantity of gases through passages actually identical but which bear an increased relation of 28 per cent. to the grate area when compared to the prior case.

When discussing another phase of the subject Wm. Kent gives us the following, which may be taken as bearing on this subject: "Where two competing boiler makers offer boilers of the same type and same extent of heating surface, that one should be preferred, other things being equal, which has the larger grate surface. Too large a grate surface is an evil that may easily be remedied by shortening the grates, but too small grate surface necessitates the use of higher priced coals, entails more labor in handling fires, and consequent loss of economy." It would seem that Mr. Kent's opinion is that the ratios we have been discussing are of less importance than an unlimited grate area. Would not the more rational way be to build the setting and proportion the grate and boiler to the quality of coal it is desired to use and to the exact amount required?

Before taking up the rate of combustion it is instructive to glance through a few examples which show the wide difference that exists in Indianapolis practice. In the VanVorhis Building there is a 12x43-in. boiler having 42 2-in. tubes. The ratio of grate to heating surface is 1:9, and of grate to tubes, 21:1. Scarcely better than this is the plant at Tomlinson Hall, where the ratio of grate to heating surface is 1:21; the ratio of grate to tubes, 12.5:1; the ratio of grate to breeching, 4.5:1. The sudden change in area of nearly 300 per cent. when passing from the tubes to the breeching deserves notice. At this plant the stack draft was 1½ in. with the furnace draft less than 0.1 in.

At the National Biscuit Co. plant there are two boilers side by side, of the same type and made by the same firm, but of different sizes. Boiler B was installed some time after boiler A was put in.

	Boiler A.	B.
Ratio grate to heating.............	1:20	1:48
Ratio grate to tubes..................	8.2:1	5.1:1
Ratio grate to chimney.............	7.1:1	3.6:1
Chimney height.....................	60 ft.	54 ft.
Grate	shaker.	plain.

The ratios in boiler B are about double those in boiler A and A has a shaker grate and 6 additional feet of chimney height. Notwithstanding the disadvantages of grate and chimneys, B has the best draft, which is of course due to the increased area of the flues and chimney.

One of the best hand-fired plants in Indianapolis is at the Traction Building, where we find the following: Grate to heating surface, 1:55; grate to tubes, 4.1:1; grate to chimney, 3.6:1; the furnace draft is 0.4 in. An example of a furnace built to burn a specified amount of a given coal, is at the French Steam Dye Works. Here the ratio of grate to heating surface is 1:56; grate to tubes, 5.7:1; grate to chimney, 4:1; the furnace draft is 0.3 in. At both the Traction Building and the Dye Works a high rate of combustion is maintained with a poor grade of nut and slack coal.

The rate of combustion is dependent on the chimney height and on the grate area. It is a well-established fact that a high rate of combustion with bituminous coal means higher efficiency and this can only be obtained by increased chimney heights and contracted grate areas. Tube areas have become more standard than formerly and the movement is toward larger tubes for the bituminous coal districts. These are not as a general thing in the hands of power plant designers, having been fixed by custom and the boiler makers, but chimney heights and grate areas can be changed to suit conditions.

The sizes usually sold by reliable builders, as given in their catalogues, are as follows, the combustion being figured at rating and 5 lbs. coal per h.-p.-hour:

Co. A.	H.P.	Chimney—ft.	Rate—lb.
Minimum	50	40	14
Maximum	150	60	23
Average	—	46	17.8
Co. B.			
Minimum	50	40	14
Maximum	140	51	23.5
Average	—	.45	17.4

Now let us look at the rates of combustion of actual plants with so-called standard setting and chimney less than 100 feet high.

Chimney.	Rate, lb.	Chimney.	Rate, lb.	Chimney.	Rate, lb.
1. 40 ft...	8	5. 70 ft...	22	9. 90 ft...	7.3
2. 40 ft...	10.8	6. 80 ft...	5.5	10. 90 ft...	16.0
3. 50 ft...	11	7. 80 ft...	9.5	11. 97 ft...	13.5
4. 70 ft...	10	8. 85 ft...	7.4	Av. 72 ft...	10.3

These plants were selected at random and represent average practice in this city. Only one shows a rate higher than 20 lb. and that is where a steam jet is used.

A chimney formula suggested by the Stirling Co. assumes a fixed diameter for a given horsepower. It is evident that such a formula can only be used for those cases where a certain rate of combustion gives the required capacity of the boiler, owing to the fact that any decrease in chimney height retards the movement of the gases, thus decreasing the effective draft.

The empirical formula of Wm. Kent is more rational but is open to the serious objection that its application may be taken too broadly. Take for instance a plant of 600 h.-p., which can be served by a chimney 100 ft. high and 63 in. in diameter, or by one 170 ft. high and 57 in. in diameter, obviously the lower chimney is the cheaper to build and for that reason in most cases would be built.

At this point we may bring to the rescue a chart, by the Stirling Co., which gives curves showing the amount of coal that can be burned with various effective draft powers. Whether these curves are correct for general practice or not, is immaterial at this time, but having these curves once established for any one type of furnace we may, with a knowledge of the resistance of various boilers, assume a chimney height for any desired rate of combustion and the diameter immediately comes out of Kent's table.

In the present state of the art, there is but one safe way to get a modern plant, and that is to discard the cut and dried practice of the last 50 years and to take as a model some successful plant, of which we fortunately have a few.

In closing, let me offer another thought. Many plants are so constructed that it is possible by careless and inefficient handling to render them exceedingly wasteful. Why not build plants so that in order to maintain a certain capacity, the operator must be constantly on the alert and the plant at all times be handled properly? The designer who goes up against this kind of a proposition is bound to get some hard knocks, but such a policy must result in greater skill on the part of the operator, and a higher standard of every-day, commercial, plant efficiency.

Concrete Aggregates.

A paper read before the National Association of Cement Users by Sanford E. Thompson, Consulting Engineer, Newton Highlands, Mass.

The term "aggregate" includes not only the stone but also the sand which is mixed with cement to form either concrete or mortar; in other words, it is the entire inert mineral material. This definition, now generally accepted, has replaced the one restricting the term to the coarse aggregate alone. It is the object of this paper to enumerate briefly the general principles which should be followed in the selection of sand and stone for mortar and concrete, and to describe briefly the method of testing aggregates and determining proportions which the author has found to give good results in practice.

At the outset it may be said that a concrete of fair quality, if rich enough in cement, can be made with nearly any kind of mineral aggregate, but there is nevertheless a wide variation in the results produced. For the fine aggregate, sand, broken stone, screenings, pulverized slag or the fine material from cinders may be used separately or in combination with each other. For the coarse aggregate, broken stone, gravel, screened gravel, slag, crushed lava, shells, broken brick or mixtures of any of these may be employed. However, the very fact of the adaptability of concrete to so wide a range of material, every one of which really consists of a large class varying in size, shape and composition, tends to blind one to the economies which often may be effected and the improvement in quality which almost always will result by a careful selection and proportioning of the aggregates.

In many cases, especially where the cost of Portland cement is low, it may be cheaper to use whatever materials are nearest at hand, and insure the quality of the concrete or mortar by making it excessively rich in cement. If the structure is small and of little importance this course is properly followed, but on the other hand, if a large amount of concrete is to be laid, and especially if the process is to be carried on in a factory, as in concrete block manufacture, it pays from the standpoints of both quality and economy to use great care in the selection of the aggregates as well as of the cement and to provide means for maintaining uniformity.

To illustrate the variation which different aggregates may produce even when they are mixed with cement in the same proportions, the author has selected a few comparative tests of mortar and concrete.

Effect of Different Aggregates.—Tests by Mr. Rene Feret, of France (see Taylor and Thompson's "Concrete, Plain and Reinforced," p. 136), with mortar made from different natural sands show a surprising variation in strength, which is evidently due simply to the fineness of the sand of which the different specimens are composed. Selecting from his results proportions 1:2.5 by weight; that is, one part cement to 2½ parts sand, and converting his results at the age of five months from French units to pounds per square inch, the average tensile strength of Portland cement mortar made with coarse sand is 421 lb. per square inch, with medium sand 368 lb. per sq. in., with fine sand 302 lb. per sq. in. In the crushing strength, usually the most important consideration, the difference is even more marked. In round numbers, at the age of five months the mortar of coarse sand gave 5,200 lb. per sq. in., the medium sand 3,400 lb. per sq. in., and the fine sand 1,900 lb. per sq. in. Note that the different sands were not artificially prepared, but were taken from the natural bank, and correspond to those which every day are being used for concrete and mortar.

The effect of different mixtures of the same kind of material is shown by tests with which the author has been connected during the past year, but the results of which have not yet been published. By varying the sizes of the particles of the aggregates, but using in all cases stone from the same ledge and the same proportion of cement to total aggregate by weight, namely, 1:9 (or approximately 1:3:6), he found it possible to make specimens the resulting strengths of some of which were 2½ times the strength of others.

The effect of the hardness or strength of the stone used for the coarse aggregate is shown in tests by George W. Rafter (second Report on Genesee River Storage Project, 1894), which, for proportions about 1:2:6:5, gave 50 per cent. greater compressive strength of concrete where the coarse aggregate was a hard sandstone than, with similar proportions, where a shale was substituted. In some of his tests the harder stone gave a concrete even double the strength of the concrete with the softer stone.

Selecting Stone.—The quality of concrete is affected by the hardness of the stone, the shape of the particles, the maximum size of the particles, and the relative sizes of the particles.

If broken stone is used and there is an opportunity for choice, the best is that which is hard, with cubical fracture, with particles whose maximum size is as large as can be handled in the work, with the particles smaller than, say, ¼ in., screened out to be used as sand, and with the sizes of the remaining coarse stone varying from small to large, the coarsest predominating.

If the gravel is used it must be clean. The maximum size of particles should be as large as can be handled in the work; grains below, say, ¼ in., should be screened out to be used as sand, and the size of the stones should vary, with the coarsest predominating.

I have said that the size of the coarsest particles of stone should be as large as can be handled in the work. This is because the strength of the concrete is thereby increased, and a leaner mixture can be used than with small stone. In mass concrete the stones, if too large, are liable to separate from the mortar unless placed by hand or derrick, as in rubble concrete, and a practical maximum size is 2½ or 3 in. In thin walls, floors and other reinforced construction, a 1-in. maximum size is generally as large as can be easily worked between the steel. In some cases where the walls are very thin, say, 3 or 4 in., a ¾-in. maximum size is more convenient to handle.

It is a little more trouble, but almost always best, to screen out the sand from gravel, or the fine material from crusher stone, and then re-mix it in the proportions required by the specifications, for otherwise the proportions will vary at different points, and one must use and pay for an excess of cement to balance the lack of uniformity.

If the gravel is used it is absolutely essential that it shall be clean, because if clay or loam adhere to the particles, the adhesion of the cement will be destroyed or weakened. Tests of the Boston Transit Commission (Report for 1901, p. 39) give an average unit transverse strength of 605 lb. per sq. in. for concrete made with clean gravel as against 446 lb. per sq. in. when made with dirty gravel.

Values of Different Stone.—Different stones of the same class vary so widely in texture and strength that it is impossible to give their exact comparative values for concrete. A comparison by the author of a large number of tests of concrete made with different kinds of stone indicates that the value of a broken stone for concrete is largely governed by the actual strength of the stone itself, the hardest stone producing the strongest concrete. This forms a valuable guide for comparing different stones. Comparative tests indicate that different stones in order for their value for concrete are approximately as follows: (1) Trap, (2) granite, (3) gravel, (4) marble, (5) limestone, (6) slag, (7) sandstone, (8) slate, (9) shale, (10) cinders. Although, as stated above, the wide differences in the quality of the stone of any class make accurate comparisons impossible—and this difficulty is increased by the fact that the proportions and age of the specimens affect their relative value—an approximate estimate drawn from actual tests, gives the value for concrete of good sandstone as not more than three-fourths the value of trap, and the value of slate as less than half that of trap. Good cinders nearly equal slate and shale in the strength of concrete made with them.

The hardness of the stone grows in importance with the age of the concrete. Thus gravel concrete, because of the rounded surfaces, at the age of one month may be weaker than a concrete made with comparatively soft broken stone, but at the age of one year it may surpass in strength the broken stone concrete because as the cement becomes hard there is greater tendency for the stones themselves to shear through, and the hardness of the gravel stones thus comes into play. Gravel makes a dense mixture, and if much cheaper than broken stone can usually be substituted for it.

A flat grained material packs less closely and generally is inferior to stone of cubical fracture.

Selecting Sand.—The only characteristics of sand which need be considered are the coarseness of its grains and its cleanness. These qualities effect the density of the mortar produced and therefore the test of the volume of mortar, or "yield," determines which of two or more sands is best graded. The "yield" or volumetric test I consider of greater value for quick results than all others put together. The methods of employing it are described further in this paper.

The best sand is that which produces the smallest volume of plastic mortar when mixed with cement in the required proportions by weight.

A high weight of sand and a corresponding low percentage of voids are indications of coarseness and good grading of particles; but because of the impossibility of establishing uniformity in weighing or measuring, they are merely general guides which cannot under any conditions be taken as positive indications of true relative values. The various characteristics of sands are separately considered in the following paragraphs.

A heavy sand is generally denser, and therefore better than a light sand. However, this is not a positive sign of worth, because the difference in moisture may affect the weight by 20 per cent., and when weighed dry the results are not comparable for mortars, since a fine sand takes more water than coarse. As an illustration of the variation in weight of natural sands having different moisture, the author found that the weight per cubic foot of Cow Bay sand, which, dry, averaged 103 lb. when placed out of doors, and weighed after a rain in exactly the same way (although it was allowed to drain for two days) averaged 83 lb.

The voids, like the weight, are so variable in the same sand, because of different percentage of moisture and different methods of handling, that their determination is of but slight value. In the Cow Bay sand just mentioned the voids were 38 per cent. in the dry sand, and 52 per cent. in the same sand, moist. Because of such discrepancies the author prefers to mix the sand with the cement and water, and determine the void in the fresh mortar, as described later. This gives a true comparison of different sands, since with the same percentage of cement, the mortar having the lowest air plus water voids is the strongest.

A coarse sand produces the densest, and therefore, the strongest mortar or concrete. A sufficient quantity of fine grains is valuable to grade down and reduce the size of the voids, but in ordinary natural material, either sand or screenings, there will be found sufficient fine material for ordinary proportions, such as 1:1, 1:2 or 1:2½. For leaner proportions such as 1:4 or 1:5, and sometimes 1:3, an addition of fine particles will be found advantageous to assist the cement in filling the voids. A dirty sand, that is, one containing fine clay or other mineral matter, up to say, 10 per cent., is actually found by tests to be better than a clean sand for lean mortars. For water-tight work it is probable that a larger proportion of very fine grains may be employed than for the best results in strength. This is a question, however, which has not yet been thoroughly investigated. Feret's rule for sand to produce the densest mortar is to proportion the coarse grains as double the fine, including the cement, with no grains of intermediate size. There is difficulty in an exact practical application of this rule, but it indicates the trend to be followed in seeking maximum density and strength.

An excess of fine material or dirt, as has just been noted, weakens a mortar which is rich in cement. It may also seriously retard its setting. My attention was recently called to a concrete lining, one portion of which failed to set hard for several weeks, although the same cement was used as on adjacent portions of the work. The difficulty proved to be due entirely to the fact that the contractor substituted in this place a very fine sand, the regular material happening to run low.

Notice that the quality of sharpness has not been mentioned among the essential characteristics of sand. This omission was intentional. The majority of specifications still call for "sharp" sand, and yet I have never known—and I venture to predict that none of those present have ever known—a sand to be rejected simply because of its lack of sharpness. As a matter of fact, if two sands have the same-size grains and contain an equal amount of dust, that one with rounded grains is apt to give a denser and stronger mortar than the sharp-grained sand. A sand with a sharp "feel" is preferable to another, not to any extent because of its sharpness, but because the grittiness indicates a silicious sand which is apt to have no excess of fine material.

Many comparative tests of sand and screenings have been made with contrary results; while frequently crusher screenings produce stronger mortar than ordinary sand, the author in an extensive series of tests has found the reverse to be true. This disagreement is probably due to the grading of the particles, although in certain cases the screenings may add to the strength because of hydraulicity of the dust when mixed with cement.

Testing Sand.—In the previous paragraphs are shown the defects in the more common methods of examining sand. I now venture to propose a test for sand which I am using constantly in my experiments for clients. Tests which I made in 1903 proved to me the value of the principles of density of mortars laid down by Feret, and in the winter of that year similar plans for testing aggregates were introduced by Mr. Wm. B. Fuller and myself at Jerome Park Reservoir, New York City. The object of the test is to determine which of two or more sands will produce the denser, and therefore, the stronger mortar, in any given proportions. From the results of tests, the relative strengths of two different mortars can be approximately estimated without resorting to actual tensile or compressive tests.

In opening this paper I have given the dif-

In opening this paper I have given the different results in strength which Feret found with coarse, medium and fine sands respectively, these relative strengths in compression being respectively 5,200, 3,400, and 1,900 lb., with proportions 1:2½ by weight in each case. An examination of the tests shows that the strongest mortar was also densest; that is, the smallest volume or yield of mortar was produced with a given weight of aggregate.

The mortar with medium sand occupied a volume 7½ per cent. in excess of the volume of the mortar with coarse sand, and the mortar of fine sand, a volume 17 per cent. in excess of the mortar with coarse sand.

Following these principles, two sands may be compared and the better one selected by determining which produces the smallest volume of mortar with the given proportions by weight. Using the method described below, the author has been able to increase the strength of a mortar about 40 per cent. by merely changing the sizes of grains of the aggregate.

The method of making the test is as follows: If the proportions of the cement to sand are by volume, they must be reduced to weight proportions; for example, if a sand weighs 83 lb. per cubic foot moist, and the moisture found by drying a small sample of it at 212° Fahr. is 4 per cent., which corresponds to about 3 lb. in the cubic foot, the weight of dry sand in the cubic foot will be $83 - 3 = 80$. If the proportions by volue are 1:3, that is, 1 cu. ft. dry cement to 3 cu. ft. of moist sand, and if we assume the weight of the cement as 100 lb. per cubic foot, the proportions by weight will be 100 lb. cement to $3 \times 80 = 240$ lb. sand, which corresponds to proportions 1:2.4 by weight.

A convenient measure for the mortar is a glass graduate about 1½ in. diameter, graduated to 250 c.c. A convenient weight of cement plus sand for a test is 350 grams. For weighing I employ Harvard Trip scales, which weigh with fair accuracy to 0.1 gram. The sand is dried and mixed with cement in the calculated proportions in a shallow pan about 10 in. in diameter and 1 in. deep. The mixing is conveniently done with a 4-in. pointing trowel. The dry mixed material is formed into a circle, as in mixing cement for briquettes, and sufficient water added to make a mortar of plastic consistency similar to that used in laying brick masonry. After mixing five times the mortar is introduced about 20 c.c. at a time into the graduate, and, to expel any air bubbles, is lightly tamped with a round stick with a flat end. The mortar is allowed to settle in the graduate for one or two hours until the level becomes constant, when the surplus water is poured off, and the volume of the mortar in cubic centimeters is read. For greater exactness, a correction may be introduced for mortar remaining on pan and trowel. The other sands which are to be compared with this one are then mixed with cement in the same proportions by dry weight, and sufficient water added to give the same consistency. The percentage of water required will vary with the different aggregates, the fine sand requiring the more water. After testing all the mortars, the sand which produces the strongest mortar is immediately located as that in the mortar of the lowest volume. By systematic trials, the best mixture of two or more sands may also be found.

In some cases a correction must be introduced for the specific gravity of the sand; for example, ordinary bank sand has an average specific gravity of 2.65, but if this is to be compared with broken stone screenings having a specific gravity of, say, 2.80, the proportions of the two must be made slightly different.

In making these tests, it is also important to notice the character of the mortar as it is being mixed. It should work smooth under the trowel and be practically free from air bubbles.

Strengths of Mortars.—From the results of the tests described, it is possible to estimate very closely the relative strength of different mortars made with the same cement. A formula is given by Feret (See Taylor and Thompson's "Concrete, Plain and Reinforced," p: 139), for calculating the strength from the absolute volumes of the ingredients of the mortar, but wishing to avoid the calculation of the absolute volumes and obtain the result directly from the weights of the materials and the volume of the mortar made from them, I have found it possible to evolve from Feret's formula one which makes use only of the data from the test in the graduates above described. The formula is as follows: Let P = compressive strength of mortar in pounds per square inch; K = a constant; Q = measured volume or quantity of mortar in cubic centimeters; C = weight of cement used in grams; S = weight of sand used in grams; Gc = specific gravity of cement; Gs = specific gravity of sand.

$$\text{Then } P = K\left(\frac{Gs}{Gc}\right)^2\left(\frac{C}{Gs\,Q - S}\right)^2$$

This formula may be readily altered to apply entirely to the English system of weights and measures.

The value of K varies with different cements and different ages of the same mortar. Hence, it is simplest to disregard the actual strength, and consider the relative strengths of any two or more mortars as in direct proportions to the values of the square of the quantities in brackets.

If the aggregates to be compared have similar specific gravity as is the case with different natural sands, the relative strengths of the mortars will be in proportion to the values of $[C \div (Gs\,Q - S)]^2$.

Road Repairs.

In a report recently made to the New Jersey State Road Commissioner by Mr. James Owen, M. Am. Soc. C. E., engineer of Essex county, it is pointed out that the repair of the State roads will be, in the future, a matter of more care and solicitation than at the present, and with the increasing use of the highways for different kinds of travel the means and methods of repair may have to undergo considerable modifications to completely fill the public want. In the first place, Mr. Owen mentions that the public mind has been educated to such a high standard that medium or inferior surfaces will not be tolerated. Second, the demand for a higher standard has been generally accompanied with a willingness to furnish the necessary money for the purpose. Third, the accomplishment and maintenance of a proper surface to the highway has resulted in a vast increase of vehicular travel, rendering the wear much greater. Fourth, this increase of travel is not only in the number of vehicles but in the enormous increase of weight and load of each, especially in motor cars. The problem, therefore, is to consider all the elements of wear and tear and devise the proper methods to overcome them.

The process of deterioration in any given road is due, Mr. Owen says, to the following causes:

From travel; the hammering of horses' feet, which tends to loosen the surface; the pounding of the wheels wearing the stones out; the displacement of the surface due to the undue loads without sufficient support; the displacement of tie surface from the high velocity and extreme weight of automobiles.

From weather; the breaking up of the road surface due to frost in winter, and in dry weather in summer; the softening of the surface in excessive rains; the destruction of surface from heavy washes from the same cause.

Taking the above list they can be classified as either perennial or incidental and the treatment in each case may vary. The action of horses' feet occurs only in narrow roads, little used, with a single line of travel, or in the spring of the year when the snow is disappearing and the long caulks of the horses root up the stone. The first trouble is hard to get over, except with a coating of screenings, sand or loam, and is apt to be continuous with the conditions noted. The second trouble generally disappears with the spring rains. The grinding up of the surface material by the wheels of course can only be replaced by the insertion of similar material. The displacement of the surface due to heavy loads, which generally appears in the form of ruts in macadam roads, can be obviated either by recoating the road, or filling up the ruts. In filling the ruts, however, the edges of the ruts should be picked over to a width of 6 in. before the new material is put on.

The displacement of the surface due to automobiles is becoming a subject of grave solicitation in the repair question. There seems, in Mr. Owen's opinion, to be double action in the process, viz., first, a grinding action somewhat similar to the ordinary wheel travel, and, second, a kicking action, throwing the loosened material to the side. In dry, dusty weather the surface of a macadam pavement, after the passage of a heavy automobile at a high velocity, shows an incipient rut of light dimensions, but plainly to be discerned. This is not like the rut formed by ordinary vehicles just displacing the dusty surface, but is due to the tearing out of a portion of the consolidated macadam, and the result is manifestly a great increase in the rate of deterioration. Fortunately automobiles do not travel a straight line like a horse and wagon, and the tendency to continuous ruts is not apparent, and so far there is no tendency of the automobiles to break up the surface in any more serious manner. With the steady increase of their use, however, such a condition might arise.

The repairs due to the action of weather can be handled, Mr. Owen says, as follows: The breaking up of the surface by frost means with macadam either a releveling of the surface before it is dried out, or recovering with stone. Such an occurrence with Telford is very rare, but when it does happen it necessitates relaying the road in the part affected. When the surface is broken in dry weather, a coating of screenings, loam or sand is absolutely necessary unless rain intervenes. The softening of the surface by excessive rains is incidental to the work, but can be greatly modified by good grades and plenty of crown, thereby shedding the water quickly.

In the treatment of the destruction of surface by heavy rains the degree of damage governs the methods. In many cases wear will be sufficient, but if gullies are washed, fresh stone should be put in, and if a dry spell succeeds the rain, screenings or loam may be required.

The renewal of the surface made necessary from any of the above causes, should be made with the same care and on the same principle as the original construction. The material and methods are of course subject to locality, but it is safe to say that the business of building and repairing roads is as much an expert matter as building railroads and bridges, and only those with full knowledge of their business should be put in authority.

In the early part of the last century railroads superseded highways, but with the introduction of mechanical propulsion on our roads, their use has been so vastly increased that their construction and maintenance is on a par with railroads in importance and demands the same skill and intelligence.

Book Notes.

The seventh annual number of the "Architects' Directory and Specification Index" retains the peculiar character of contents of previous numbers. It is not only a directory of architects but also a classified list of makers of building materials and supplies and other people interested in the construction of buildings. The list of architects covers Canada as well as the United States and is arranged by States, with the cities of each State in alphabetical order. Those who are members of architectural societies are so designated. The dealers are classified by the materials they supply, and some of the larger firms are under many heads. The purpose of this list is to afford the architect a list of people to whom to apply for catalogues or estimates on any kind of supplies which he is called upon to specify. The book also contains a list of the chapters and their officers in the American Institute of Architects, and a similar list of the societies in the Architectural League of America. Lists of architectural schools, societies and periodicals and a statement of the professional charges adopted by the American Institute are also given. (New York, W. T. Comstock; cloth, 8vo, $2.)

The first sentence of Mr. William Baxter's "Practical Talks on Electricity" explains the idea which underlies the book: "In this electrical age the engineer who understands the principles upon which electrical machines act well enough to be able to doctor them when an unimportant disorder interferes with perfect action, or who can determine the nature of the required repairs, when these are of such a character that outside assistance is necessary, has a great advantage over his brothers whose information is limited strictly to the action of the steam engine." In other words, the engineer of an isolated plant must be sufficiently acquainted with the nature of electrical apparatus to understand its principles thoroughly, although its actual design in detail, involving the computations of its dimensions, does not concern him. Accordingly the author of this little handbook has kept his text free from all mathematics, confining it to subjects which the operating engineer is rightfully supposed to know. The text is divided into two parts, the first devoted to the principles and construction of dynamos and switchboards and the second mainly to the care and management of dynamos and motors, although there are some sections of it referring rather to the construction of switchboard apparatus than to its care. In fact, the arrangement of the chapters has been evidently adapted more with a view to discussing the various subjects in the manner in which they present themselves to the engineer than in the usual schoolbook way in which everything concerning switchboards, for example, is collected in one chapter. The first part of the book opens with some notes on the elementary principles of electricity and magnetism, and one of the sentences from it will illustrate better than many paragraphs of criticism the view-point of the author. This sentence reads: "It matters little whether or not we know absolutely what electricity and magnetism are, so long as we know what they will do and the conditions under which they do it." The chapters that follow take up electromagnetic fields and field coils, commutation types of dynamos, the winding of armatures, armature reaction and sparking of the commutator bushes, multipolar machines, and the various windings of their armatures, the formation of armature coils, the connection of generators with the distributing circuit, the connections of switchboards, the three-wire system, the construction of switches, the construction of switchboards, ammeters and other switchboard apparatus in regular use, the connections of these instruments, and integrating wattmeters and their connection. The second part of the manual opens with a chapter on using galvanometers, after which the care of electric machines, management of generators, the parallel operation of generators, changing the voltage of generators, grounds and field short-circuits, repairing short circuits in armatures, finding and repairing broken wires in armatures, the connection of shunt-wound motors with the supply wires, changing the speed of motors, motor starters and controllers, no-voltage and overload motor starters, motor controllers, reversing motor controllers, motor controllers for printing presses, motor starters with electromagnetic switches, testing electric motors, and generators and storage batteries. The author's long experience with electric machinery has enabled him to prepare a thoroughly good book for the operating engineer, which is particularly valuable because written with entire freedom from any abstruse technicalities. (Chicago, The Engineer Publishing Co.; cloth, 16mo, $2.50.)

ELECTRIC POWER TRANSMISSION. A Practical Treatise for Practical Men. By Dr. Louis Bell. New York, McGraw Publishing Co.; cloth, 8vo, 721 pp., $4.00.

The development of electric power transmission since the appearance of the first edition of this work nine years ago has been followed by equal enlargement of the book, in spite of the pruning process by which Dr. Bell has eliminated from successive editions all reference to obsolete equipment and methods having but trifling historical value. A comparison of the first and present editions, however, affords a very interesting view of the development of the art, in which the author himself has played an important part which he modestly refrains from mentioning in any way. In no wise, perhaps, is this progress more concisely indicated than in the revision of the table of high voltage transmission plants; since 1897 plants of 10,000 volts have become so "utterly commonplace" that it is a hopeless task to keep track of them, and in the list published in the latest edition of the book plants of less than 20,000 volts are not included.

The old order of contents is retained. It begins with a statement of the elementary principles of the subject and the general conditions of power transmission. Power transmission by continuous currents is then taken up, and it is interesting to observe the author's comment on the Thury system, now so much in the public eye: "To tell the unvarnished truth, a constant-current transmission coupled with a three-wire distribution at 220 to 250 volts on a side is capable of giving even the best alternating system a pretty hard rub over moderate distances." The three following chapters are on the properties of alternating currents, power transmission by alternating currents and alternating current motors, and retain all those features of exceptional lucidity which made this part of previous editions so popular with both students and engineers. A brief chapter on current reorganizers is followed by discussions of steam plant, water-wheels and hydraulic developments. The remaining portions of the book contain most of the changes that have taken place in the preparation of the new edition. The chapters take up in order the organization of a power station, auxiliary and switchboard apparatus, the line and its construction, methods of distribution, the commercial problem, the measurement of electrical energy, and high-voltage transmission. The improvements in line construction and station apparatus in recent years have not been of great novelty although so important in effect that many parts of the book relating to such equipment have been rewritten or materially enlarged.

A book so well known as this does not need extended review, yet it may properly be said that it is, as the author states on the title page, a practical treatise for practical men. It describes the present condition of electric power transmission in all parts of the world, explains the principles involved in such work and takes up the apparatus in sufficient detail to enable any technically educated man to become well acquainted with the whole subject. It is not a mere description of apparatus, but an explanation of what the apparatus may be expected to do when properly installed. It is full of critical comments of features of design, both of equipment and installations. It is wholly unbiased by any commercial considerations and represents the mature judgment of an engineer who played a leading part in the development of the early transmission plants in this country and has ever since been an acknowledged authority on the subject.

Letters to the Editor.

WATER WORKS IMPROVEMENT IN PHILADELPHIA.

SIR: For the last fifty years Philadelphia has had the betterment of its water supply under consideration, but seems to be no nearer the solution to-day, after almost attaining the goal of its hopes. Until the last few months all questions seemed to have been settled, but after it was supposed that the subject had been exhausted and all the talent possible employed it now appears this was all a mistake; all is wrong. Major Cassius E. Gillette, U. S. A., criticizes Mr. John W. Hill, M. Am. Soc. C. E., for making changes in the engineering plans suggested by the Commission of 1899 for the filtration plant, "in three important particulars, viz.: The construction of the Torresdale conduit; the transfer of the Queen Lane filters to Torresdale, and the construction of the Oak Lane reservoirs, making it appear that these changes were made to increase the work of construction for the direct and only purpose of defrauding the city, and without regard to the engineering benefits obtained.

If the geography and topography of the sources of water supply, and also of the areas in the city to be supplied, had been carefully studied by Major Gillette, he would not have fallen into error. The sources of water supply under consideration are the Schuylkill and Delaware Rivers. Considering these sources without regard to their present pollution, and also that sooner or later storage dams must be constructed on both streams to equalize their flow, we may compare their respective drainage areas with areas of the city most contiguous and convenient for their use.

The Schuylkill River has a drainage area of 1,900 square miles, and the Delaware above Philadelphia, of 8,000 square miles. The city is entitled to the water from a catchment area, in the Delaware, of 4,200 square miles. This makes the total catchment area of both rivers available for the city supply 6,100 square miles.

The area of the city is approximately 130 square miles, which makes an apportionment of 47 square miles of catchment area in the rivers to each square mile of city area. West Philadelphia has an area of approximately 23 square miles, which, multiplied by 47, equals 1,081 square miles of drainage area. The high ground east of the Schuylkill, in Manayunk, Roxborough, Mt. Airy and Germantown, has an area of over 18 square miles, which, multiplied by 47, equals 886 square miles of drainage area, making a total of 1,967 square miles of drainage area, or about that of the Schuylkill River watershed. The remaining area of the city, 89 square miles, multiplied by

47 square miles, will make up the 4,200 square miles available from the Delaware River watershed.

Mr. Hill has evidently followed some such method of reasoning, which establishes pumping stations on the Schuylkill, at Belmont for West Philadelphia and at Roxborough for the high ground east of the Schuylkill, and eliminates the Queen Lane plant. Mr. Hill has been criticized for abandoning this Queen Lane outfit. This plant was constructed about 1896, not only after great public excitement, and against not only popular but engineering protest. Reasons were urged at the time of its inception that this station was a mistake, and that it should not be built, but that the money appropriated for it should be used to enlarge Belmont and construct a reservoir in West Philadelphia at an elevation of 250 ft., which could be used at that time to supply such parts of the city east of the Schuylkill as was required, and that in the future it would be serviceable in the supply of West Philadelphia, when the city east of the river was supplied from the Delaware. This station was and always has been a misfit, and Mr. Hill is to be congratulated, not only upon his wisdom, but also upon his courage, in its abandonment.

Mr. Hill is condemned for the construction of the Oak Lane reservoir. This reservoir occupies a unique position almost in a geographical center of distribution for the area to be supplied from the Delaware River, at an elevation higher than any of the area to the northeast, except about 2 square miles in the extreme northern corner of the city. Its position is such that it occupies the logical and ideal location for an auxiliary pumping station to supply the high ground to the west and south, which cannot be supplied by Roxborough, and is now but sparsely settled. This Oak Lane reservoir can also be used to supplement and co-ordinate the supply from the Schuylkill River. An examination of the topography of the city will make this evident.

No one who understands topography can dispute the value of this location; in fact, it was selected by the writer 30 years ago, when the Lardner's Point pumping station was built. Subsequently, Mr. John W. Ledoux, M. Am. Soc. C. E., chief engineer of the Springfield Water Co. called attention to it in a scientific paper, which was printed and had wide circulation. Mr. Hill could not, as an engineer, ignore the importance of this location, even if the Commission of 1899 did not know of it, and he would have been censured if he had not used it.

Mr. Hill is condemned for not establishing a high service pumping plant at Torresdale, and also for the construction of the tunnel conduit. Lardner's Point pumping station was built in 1877. The selection of this site was by Dr. Wm. H. McFadden, then chief engineer. Some of the many reasons for this selection are, that from it the shortest pumping mains could be laid to points of distribution, and that it had excellent facilities for coal storage and for the supply of coal from both river and rail. Mr. Hill evidently appreciated these conditions, and adopted the location for the main pumping station, instead of Torresdale.

The conduit, which is also a subject of criticism by Major Gillette, must be credited to the engineering mind of Mr. Hill, and for which he should be not only praised but thanked. This tunnel, nearly 3 miles long, connects the clear water basin at Torresdale with the Lardner's Point pumping station. Major Gillette thinks that the pumping station should have been located at Torresdale, and that cast-iron pumping mains should have been substituted for the tunnel. No engineer who has had any experience in the design and operation of water works selects a plan requiring long pumping mains, if he can avoid it. The danger from breakage and leaks can only be appreciated by those who know. The Hill conduit eliminates from the Gillette scheme either 8 lines of iron pipes, 5 ft. in diameter, about 3 miles long, equal to a 5-ft. iron conduit 24 miles long, or 12 lines of iron pipe 4 ft. in diameter, equal to an iron conduit 38 miles in length, and this a battery of pumping mains under a head of approximately 250 ft. Mr. Gillette says that his scheme would cost $100,000 less than the conduit; what if it did? But before pressing this point it would be well if he revised his estimate.

Charles G. Darrach,
Philadelphia, Jan. 18. M. Am. Soc. C. E.

Some Qualifications for Success in Tropical Engineering.

Sir: The present apparent excess of the supply of engineers is causing the members of the profession in this country to turn their attention more to opportunities in other lands. Speaking generally, the American engineer has, up to the present time, been able to obtain remunerative employment in his own country and has thus had no particular inducement to go abroad. It is, however, becoming increasingly evident that the supply of engineers in the country will soon largely exceed the demand, and already men who look ahead a little are beginning to see that the foreign trade of the country must be extended in order to provide employment for the enormous capital invested in the engineering plants of the country.

It seems probable that the near future will see a great development of the Central and South American States, especially the tropical portions of the latter, together with the continent of Africa. Large stores of natural wealth and millions of acres of rich virgin soil await the capitalist to turn them into gold, and signs are not wanting to show that the capitalist is fully alive to the opportunities afforded for profitable investment. In past, capital has to a large extent been deterred from entering these countries by the unsettled condition of the governments and the volcanic temperament of the inhabitants, but appearances point to a more settled state of affairs and the rights of property are becoming more respected.

With the capitalist, and frequently somewhat in advance of him, goes the engineer, each being necessary to the success of the other. The commencement of work upon the Panama Canal and the consequent demand for engineers of all grades will direct the attention of the profession still more to the tropics as a field for engineers.

Tropical engineering presents many difficulties, but the most troublesome problems are connected with the "personnel" of the undertakings. The unhealthy climate and lack of proper food and consequent ill health, the inability of a man born and reared in a temperate climate to make sustained physical exertion, absence of society and the temptations to excesses of certain kinds all combine to render the task of the engineer engaged in directing operations in the tropics a difficult one. No one who is not strong and healthy and who is not naturally fitted to withstand extreme and prolonged heat should seriously consider taking up engineering work in the tropics.

In selecting engineers for service in West Africa, Ceylon and certain parts of the West Indies, the Crown agents for the colonies insist upon a most strict medical examination being made and many men who are quite fit to do good service in their own country are rejected as unfit for service in these colonies. Almost as important is the ability to take care of one's health. Doctors and hospitals are usually provided in connection with large government undertakings, but many smaller engineering works are unprovided with either, and even if they exist they are often inefficient and difficult of access. Men who do not understand how to apply the simple remedies necessary in cases of fever, colds, slight sunstroke, snake bites and simple accidents are at a serious disadvantage.

The question of food supply is an important one. Tinned meats and biscuits form the main portion of the diet in most cases, and it is not long before the beef, mutton and the various other kinds all taste alike and the appetite for tinned stuffs is entirely lost. One longs for fresh meat, vegetables and fruit. Nevertheless, it is a case of tinned meats or nothing as a rule, and unless great care is exercised one becomes run down for want of food and malaria obtains firm hold. A daily dose of lime juice, a careful avoidance of excesses in eating, drinking and smoking, together with a careful selection of the tinned stuffs so as to obtain as much variety and as good quality as possible, will do much to preserve one's appetite, and by diligent searching one can occasionally provide a change in the shape of fish, poultry or eggs. Every possible opportunity of obtaining fresh food, vegetables or fruit should be taken advantage of.

Sir Patrick Manson, M. D., the eminent tropical medicist, advises total abstinence from alcohol as a beverage, and the writer's experience of over five years in the tropics, with good health almost the whole time, confirms this. Certainly moderation in all things is very necessary.

Given health and strength and ability to take care of them, the most important qualification for success in tropical engineering is ability to handle the native labor. Except in the highest positions the engineer is of necessity in direct touch with his labor. Appearances point to the West Indies and especially the island of Jamaica as the source from whence the majority of the labor required for the carrying through of the Panama Canal and any other large engineering works which may be undertaken in Central and the tropical portions of South America will be obtained. Many hard things have been said concerning the qualities of the West Indian negro. Properly handled by thoroughly practical men who understand them, these laborers can get through a large amount of work. The cost of earthworks in Jamaica, using only hand labor and exclusive of supervision, is frequently as low as 8 cents per cubic yard, with wages at 36 cents per day.

It is, however, difficult and expensive to obtain the right kind of supervision, for to obtain the best results it requires in the supervisor a combination of tact, intelligence, judgment and firmness not often found in the ordinary American or European foreman. Under the paternal treatment of the British Government, the negro has learned to place a fairly high value upon himself and is quick to resent any real or fancied slight or ill treatment, though at the same time he appreciates the superiority of the white man, and so long as he shows himself worthy treats him with a sufficient amount of respect. If, however, the white man lowers himself by vice or is unable to command respect, he quickly finds himself unable to carry on his work properly.

The negro as a rule prefers to work by task or piece work, and does better and quicker work under this system than any other, but, being by no means devoid of intelligence, if he finds he can take any advantage of the engineer in charge in the shape of getting paid for work which he has not done or has done improperly he is quick to do so. This characteristic is, however, not confined to the negro race, and an alert man will quickly detect and punish it.

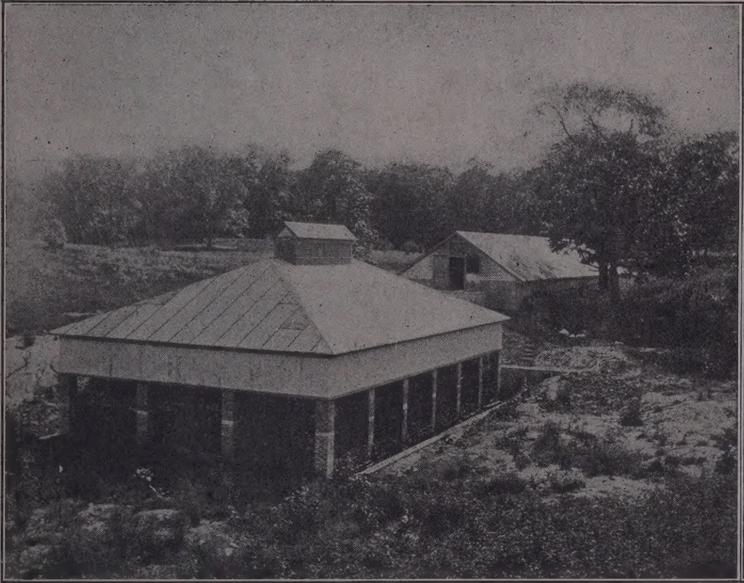
There is an inherent wrong-headedness in almost all classes of these negroes, which breaks out from time to time and calls for constant watchfulness together with great patience and determination on the part of the supervisor in order to achieve good results. Over and over again it is necessary to explain and show how the work should be done and to insist upon it being done that way and no other way, for it is their nature to only half do anything, while at the same time they probably know and certainly think that they know perfectly well how the work should be done. Generally speaking, it is necessary not only to order such and such a piece of work to be done, but also to make a point of seeing that it actually is done, for it is quite likely that it has not been done.

Shortly, they are children with a considerable amount of intelligence and cunning of a low order and, as everyone else is, in the tropics, with a strong objection to doing more work than is necessary for their comfortable existence. At the same time they are good-tempered, physically strong and, under proper management, capable of getting through a large amount of work.

Jamaica, Dec. 19. J. Monk Fletcher.

Sprinkling Filters.

Sir: I notice in an article describing the sewage purification works proposed at Columbus, Ohio, in your issue for December 30, 1905, that you state as follows: "However, the tests showed for the first time in this country that sprinkling filters could be satisfactorily operated in this northern climate."



Percolating Filter with Septic Tank in Background.

Drain Running Along Side of Percolating Filter.

I beg leave to call your attention to the fact that in 1903 I installed a purification plant for the Allis-Chalmers Co., at West Allis, Wis., which consisted of a septic tank, anaerobic filter and percolating or sprinkling filter, which is now in operation for its third winter. I enclose photographs of the plant, and will say that no enclosure is made of the percolating filter other than to set panels of boards around the filter in the winter to protect it from the direct action of wind and accumulation of snow. This plant was built by Mr. W. S. Shields, C. E., after general specification furnished by me.

Very truly yours,

Wm. S. MacHarg.

Chicago, Jan. 10.

Instruction in Railway Economics.

Sir: The writer has spent a large part of his time for the last five years in preparing and teaching a course in railway economics and he feels very great interest at the present time in getting the views of practical engineers and railway managers as to what the subject should properly embrace in undergraduate engineering schools. The writer has had extended correspondence of a personal nature on the subject with practicing engineers and engineering teachers in various institutions. But the criticisms thus received have been so flattering to his own ideas that he fears that they have been softened too much by personal considerations. He had thought of preparing a paper on the subject and offering it for discussion to the Society for the Promotion of Engineering Education. But the views thus secured would necessarily be rather from an academic standpoint, while the principal object desired is to obtain opinions on the subject from impartial practicing engineers and educated railway men.

Mr. Wellington was probably the first prominent engineer who brought into general use the term "railway economics" in connection with his well-known book on the "Economic Theory of Railway Location." As Mr. Wellington viewed the subject, from an engineering standpoint, he considered that the subject should treat entirely of the bearing that the lay-out of a new line or the improvement of an old line has upon the revenue of the road. Mr. Wellington's view was one taken principally in the interest of the stockholder.

But other writers take an entirely different view as to what the term railway economics should signify. Mr. H. T. Newcomb, the well-known railway writer and statistician, published a little work in 1898 under the title of "Railway Economics." In the preface the author tells us that the book was written "to present the principal facts which establish the position of railway transportation in the present organization of industry in the United States . . . ." The work is concerned with an historical account of the development of railway transportation and touches upon the subjects of discrimination, consolidation, pooling, taxation, etc. Little is said about the question of how to regulate railways so that they will be operated in the interest of the public that they serve as well as in the interest of the stockholders that own them. The great problem of 1904 and 1905, the control of the railway rate, had not arisen in 1898.

Early in 1903 Mr. Walter Loring Webb, formerly assistant professor of civil engineering in the University of Pennsylvania, revised and recast his work on "Railroad Construction," putting it in pocket form. Part II of this second edition consists of just 100 pages and is entitled "Railroad Economics." After the introduction the chapter headings through this part of the work are entitled: "The Promotion of Railroad Projects," "Operating Expenses," "Distance," "Curvature," "Grade" and "Improvement of Old Lines." A student can read through these 100 pages without ever learning the principle upon which freight rates are based, or without learning the fact that the laws of the land provide that the creatures of both State and National legislatures shall have great authority over railway operation and charges.

The next author with a book on railway economics is Mr. W. M. Acworth, of England, who published "The Elements of Railway Economics" early in 1905. The work is extremely brief and is confessedly incomplete, being what the author calls only an installment; but it is probably the best work for engineers yet written which includes a discussion, as applied to English railways it is true, of views on railway regulation by government authority. The object of the work, the author says in the first lines of the first chapter, "is to consider railways and railway business from the economic point of view." The viewpoint of Wellington and Webb is entirely lost by Mr. Acworth. In his view the railway is already constructed and improved and has become the chief means of transportation and intercommunication. The principal question Mr. Acworth deals with is how the railway should be regulated and operated so as to render it primarily as fair and serviceable as possible to its patrons, and, secondarily perhaps, how to make it as profitable as may be to its owners. Mr. Acworth discusses most interestingly the subjects of railway capital, income, expenditure, the bases of freight rates, freight classification and government regulation. Other interesting writers have dealt with these same subjects under different titles. Among such works that an economist or graduate engineer student can peruse with profit are Adams' "Railway Problems," Stickney's "Railway Problems," Jeans' "Railway Problems," Hadley's "Railroad Transportation," Johnson's "Railway Transportation," B. H. Meyer's "Railway Legislation," Newcomb's "Facts About Railroad Rates," Haines' "Restrictive Railway Legislation," H. R. Meyer's "Government Regulation of Railway Rates," and Noyes' "American Railroad Rates." Of course, a student working up the subject thoroughly could not neglect much other collateral matter. Various pamphlets, such as those of Joseph Nimmo, and various reports, such as those of the Interstate Commerce Commission, the report of the Industrial Commission, as well as the discussions and addresses on these questions that have appeared almost continuously of late years in the technical press.

But none of these books are suitable for even a part of a course in railway economics for undergraduates. The problem the writer is trying to solve is what should be included in a work which shall be used as a college text-book by the average student who comes to an engineering school to take the four-year course in civil engineering and then expects to enter railway service.

The writer proposes the following definition as briefly expressive of the scope of the subject as it should be taught in such a course: "Railway economics is the study of the organization, construction, extension, improvement, condition, operation and regulation of railways with reference to the public servce rendered by them and with reference to the increase of their earning power."

The writer sincerely believes that it is extremely desirable that such a student should have very capable instruction in the broader questions affecting railways. He should understand the obligations to the public imposed upon a railway by the laws of the land, by virtue of its being a public service corporation and a creation of the State, as well as the necessity of building and operating the road so as to secure the most returns upon the road's securities. He should be drilled upon the principles of incorporation and the bases of freight rates as well as upon the money value of eliminating grades, curves and distance. In short, he should be brought to look upon a railway with some insight into the general purposes of its existence and not simply as a congeries of right-of-way, roadbed, bridges, rails, buildings, terminals and rolling stock. That this is no new viewpoint in engineering education is proved, the writer believes, by the fact that Wellington's "Economic Theory" was retained so long and so generally as the standard engineering work on this subject in the best engineering institutions. That work discusses railways as they existed previous to 1886. It has certainly been almost entirely out of date for ten years or more, since by that time the various national laws that had been enacted and the various railway consolidations that had been formed had almost entirely changed the status of railway affairs from that that Wellington discussed. And yet this work was retained unrevised as a text-book in Cornell University as late as 1904. The real engineering part of railway economics treated in Wellington's great work of 950 pages has been condensed by Professor Webb into 100 pages of pocket form. Seemingly there is no valid reason why this encyclopedic work should have held its place so long in college curicula except that it gave a broad insight into the inside principles and workings that govern a railway, which insight could not be secured by the perusal of any other single work.

If the railway engineering student is ever to become something more than a purely technical railway engineer, dealing with grades, curves, steel and masonry structures, rail sections, low joints and water service; that is, if he is ever to become something more than a $1,500 or $1,800-a-year man, he needs to be drilled upon the obligations of a railway as a public service corporation and also upon its rights as a private corporation. There can be no doubt but that in the future the railway is going to be held to a much stricter accountability to its public obligations than it has been in the past, and the old-time railway official, who attempts to browbeat the public is going to be at a discount. A prediction may well be justified that the successful railway manager of even the very near future is going to be a finished gentleman rather on the student order than of the burly, grizzled, man-driving type which accomplished such excellent results under past régimes. Mr. Cassatt and Mr. Mellen are types of men very far removed from the sturdy old railway giants of past eras. The railway manager in Chicago whose system has increased its earnings in largest ratio in the last seven years is a most earnest student and in his younger days helped to devise the form of rail section that is now used by a great majority of our railways.

The writer knows from observation and some experience that the average engineer who enters young the service of a railway, who becomes well used to implicit obedience to the instructions of his superiors and to having his own instructions likewise observed by contractors and his own inferiors, is likely to absorb very greatly warped views in regard to the public obligations of the great corporation that he serves. He grows to take great pride, as he should, in the success of his company and oftentimes greatly overrates its importance. When the interest of the public and that of his corporation conflicts he comes sincerely to believe that his corporation cannot back down and that public interests must and should give way. When this engineer has become an executive officer of the company, instead of trying to arrange his train schedules and his freight facilities so as to render the best and most convenient public service possible he is disposed to say to the public that if it cannot accept the service he proposes to offer it can walk and haul its freight with an ox team.

There is no doubt but that in future, however it may have been in the past, the less there is of such a spirit among railway managers and employees the better will be its prospects for dividends. And there is no doubt in the writer's mind but that the interest of the railway will be best served if its educated employee enters its service with well-formed ideas at the beginning of the actual relative importance of the company he is serving and of its obligations as a public servant. Otherwise it will very probably in the future cost his corporation dearly to correct his misapprehension.

It is true that there have been many overt sneers at the so-called "academic" view of railway affairs and conditions, but there is no doubt but that far more comprehensive and correct views on railway geography, traffic and service can now be secured by a few months' study at the best institutions of learning than by work in the service of some great corporation. There are probably no railway men in the United States to-day who are better informed on railway subjects than the two Professors Meyer.

It is not argued here that the day has yet come when any railway in the country could profitably employ two such men as these, without practical railway experience, as vice-presidents in charge of traffic, but it is true that the railways of the country would hardly be facing such adverse legislation to-day if railway traffic men had been influenced to a somewhat greater extent in former years by a keener realization on their part of the obligations of their companies as public service corporations.

An English railway manager said in effect in an address to his own employees a little more than a year ago that the supreme test of the success of railway management was the efficiency of the public service rendered. The railroad that serves best should be best paid and will be. In the United States we are rapidly approaching the time, if indeed we have not already reached it, when railway employees and managers must perforce adopt this point of view.

Among the most frequent criticisms of his ideas that the writer has encountered has been that though it is true that such students should have training in these subjects they are not properly engineering subjects and should be taught in departments of political economy. That is precisely what the writer believes should not be done. We have long ago concluded that mathematics should be taught to engineer students by an engineer teacher, and the writer believes that both the economic and the engineer sides of railway economics can best be taught to engineer students by engineer teachers who have had some years' experience in the service of a first-class railway. Railway engineering subjects are now taught in nearly all of our better institutions by engineers who have had more or less practical experience in railway service. And the writer submits the assertion that with no more time given to the subject of railway economics than the old curricula gave to Wellington, say, three hours a week for half of the senior school year, a fairly comprehensive course, including both the so-called economic and the engineering sides of the subject, can be given.

The so-called engineering part of railway economics can be put in very brief form and is quickly and easily comprehended by advanced students. A large part of the substance included in Mr. Webb's 100 pocket-size pages of "true engineering matter" relates to subjects which Wellington carefully classified as "The Minor Details of Alignment."

While the writer appreciates to the fullest the value of the great work done by the departments of political economy in our best institutions, he believes there is an inherent difficulty in having such departments teach these subjects to young railway engineers. As such departments are at present organized in most institutions there would be danger that the engineer product of their schools would have an unpractical set of mind that could see little that was good in present railway conditions. Besides many of the teachers in these departments are somewhat wanting in practical views, having never battled at close range with business affairs. However, there are a very few institutions in the United States the product of the political economy departments of which the writer would be disposed to suspect of having a mental set very similar to that of the man who gets his training entirely in railway service. Such a man could see nothing wrong in anything that the railway might do. He would believe, as one teacher in the political economy department of the University of Chicago appears to believe, that whatever is in railway service or condtions is best and right.

Now it must be apparent that the mental set of educated railway employees is going to be a matter of very much graver moment in the future than it has been in the past. And the writer believes that it would be equally unfortunate for the average young railway engineer to absorb either the point of view of Senator La Follette, of Wisconsin, or of Prof. H. R. Meyer, of the University of Chicago. In other words, the young railway engineer student should imbibe an unbiased practical attitude of mind that will best enable him, if he ever rises to positions of authority and responsibility, to so adjust the affairs of his corporation as to comply with both the letter and spirit of its every public obligation and yet secure for it the largest possible returns on its traffic and expenditures. Of all the men in the average college faculty best fitted to give instruction calculated to impart this desirable attitude of mind to railway engineer students, they are the men who have had experience in serving both the public as teachers and the great railway corporations as engineers.

Univ. of Wis., Jan. 15. W. D. Taylor.